JAI HIND COLLEGE
BASANTSING INSTITUTE OF SCIENCE
&
J.T.LALVANI COLLEGE OF COMMERCE
(AUTONOMOUS)

"A" Road, Churchgate, Mumbai - 400 020, India.

Affiliated to
University of Mumbai

Program : B.Sc.

Proposed Course : Mathematics

Semester V

Credit Based Semester and Grading System (CBCS) with effect from the Academic year 2020-21

T.Y.B.Sc. Mathematics Syllabus

Academic year 2020-2021

	Semester V		
Course Code	**Course Title**	**Lectures /Week**	**Credits**
SMAT501	Integral Calculus	3	4
SMAT502	AbstractAlgebra-I	3	4
SMAT503	Metric Spaces-I	3	4
SMAT504	Data Analytics-I	3	4
SMAT505AC	Python and R Programming-I	4	2.5
SMAT501PR	Practical-I(Based on SMAT 501,SMAT 502)	6	4
SMAT502PR	Practical-II(Based on SMAT 503,SMAT 504)	6	4
SMAT 5AC PR	Practical-III (Based on SMAT 505AC)	4	2.5
	Total	32	29

	Semester VI		
Course Code	**Course Title**	**Lectures /Week**	**Credits**
SMAT601	Real and Complex Analysis	3	4
SMAT602	Algebra-II	3	4
SMAT603	Metric Spaces-II	3	4
SMAT604	Data Analytics-II	3	4
SMAT605AC	Python and R Programming-II	4	2.5
SMAT601PR	Practical-I(Based on SMAT 601,SMAT 602)	6	4
SMAT602PR	Practical-II(Based on SMAT 603,SMAT 604)	6	4
SMAT 6AC PR	Practical-III (Based on SMAT 605AC)	4	2.5
	Total	32	29

Course Code	Course Title	Number of Lectures	No. of Credits
SMAT501	**INTEGRAL CALCULUS**	**3**	**4**

Learning Objectives:

This course is an extension of integration theory of one variable to integration theory of multiple variable over different type of domains in $\mathbb{R}^n$.

Learning OutComes:

- This course has a wide variety of application in physics and engineering. The main objective of the course is to make students competent in solving real world maths problem.
- This course can help students to pursue research in Mathematics.

Unit I	**Multiple Integrals**	**15 L**

(a) Definition of double (respectively: triple) integral of a function bounded on a rectangle (respectively: box), Geometric interpretation as area and volume.

(b) Fubini's Theorem over rectangles and any closed bounded sets.

(c) Basic properties of double and triple integrals proved using theFubini's theorem such as; Integrability of the sums, scalar multiples, products,and (under suitable conditions). Integrability of continuous functions,

(d) Change of variables formula (Statement only), Polar, cylindrical and spherical coordinatesand integration using these coordinates.

Unit II	**Line Integral**	**15 L**

(a) Equivalence and orientation preserving equivalence of paths. Definition of the line integral of a vector field over a piecewise smooth path.

(b) Basic properties of line integrals including linearity, path-additivity and behaviour under a change of parameters, Examples.

(c) Line integrals of the gradient vector field, Fundamental Theorem of Calculus forLine Integrals, Necessary and sufficient conditions for a vector field to be conservative.

(d) Green's Theorem (proof in the case of rectangular domains). Applications to evaluation of line integrals.

Unit III	**Surface Integrals**	**15 L**

(a) Parameterized surfaces. Smoothly equivalent parameterizations, Area of such surfaces.

(b) Definition of surface integrals of scalar-valued functions as well as of vector fields defined on a surface.

(c) Curl and divergence of a vector field, Elementary identities involving gradient, curl and divergence.

(d) Stoke's Theorem (proof assuming the general form of Green's Theorem), Examples. Gauss' Divergence Theorem (proof only in the case of cubical domains), Examples.

References:

1. Apostol (1969), Calculus, Vol. 2, Second Ed., John Wiley, New York.
2. Lawrence Corwin and Robert Szczarba (1982), Multivariable Calculus, Chapman & Hall/CRC Pure and Applied Mathematics
3. J. E. Marsden and A.J. Tromba (1996), *Vector Calculus, Section 6.2 to 6.4, Fourth Ed.* W.H. Freeman and Co., New York.
4. James Stewart (2008), Calculus with early transcendental Functions, Sixth Edition, Thomson

Additional Reference:

1. T Apostol (1974), Mathematical Analysis, Second Ed., Narosa, New Delhi.
2. R. Courant and F. John (1989), Introduction to Calculus and Analysis, Vol.2, Springer -verlag, Newyork.
3. W. Fleming (1977), Functions of Several Variables, Second Ed., Springer-Verlag, Newyork
4. M. H. Protter and C. B. Morrey, Jr. (1995), Intermediate Calculus, Second Ed. Springer-Verlag, New York.
5. G. B. Thomas and R. L. Finney (1998), Calculus and Analytic Geometry, Ninth Ed.(ISE Reprint), Addison- Wesley, Reading Mass.
6. D. V. Widder (1989), Advanced Calculus, Second Ed., Dover Pub., New York.
7. Sudhir R. Ghorpade and Balmohan Limaye, A course in Multivariable Calculus and Analysis, Springer International Edition.

Course Code	Course Title	Number of Lectures	No. of Credits
SMAT502	**ABSTRACT ALGEBRA -I**	**3**	**4**

Learning Objectives:

It is a first course in Abstract Algebra. In addition to being an important branch of Mathematics in its own right, Abstract Algebra is now an essential tool in Number theory, Geometry, Topology, and, to a lesser extent, and, to a lesser extent,analysis. Thus it is a core requirement for all Mathematics majors. Algebra also has applications in Cryptography, Coding theory, Quantum Chemistry, Physics.

Learning Out Comes:

After completion of this course, the student will enable to:

- Get an insight into abstract algebra.
- Apply algebraic ways of thinking.
- Demonstrate knowledge and understanding of fundamental concepts including groups, subgroups, normal subgroups, homomorphism and isomorphism.
- Understand and prove fundamental results and solve algebraic problems using appropriate techniques.
- This course can help students to pursue research in Mathematics.

Unit I	Group Theory	15 L

(a) Groups, definition and properties, examples such as the group of prime, residue classes modulo n under multiplication, Quarternion group, Dihedral group as group of symmetries of regular polygon, abelian groups, finite and infinite groups.

(b) Subgroups, necessary and sufficient condition for a non-empty subset of a group to be a subgroup. Examples, cyclic subgroups, centre Z(G).

(c) Order of an element. Subgroup generated by a subset of the group. Cyclic groups. Examples of cyclic groups such as and the group of the n^{th} roots of unity.

(d) Cosets of a subgroup in a group. Lagrange's Theorem.

Unit II	Homomorphism and Isomorphism of Groups	15 L

(a) Homomorphisms, Isomorphisms, Automorphisms, kernel and image of a homomorphism.

(b) A finite cyclic group is isomorphic to $\mathbb{Z}_n$. An infinite cyclic group is isomorphic to .

(c) Permutation groups.

(d) Cayley's theorem for finite groups

Unit III	Normal Subgroups	15 L

(a) Definition with examples. Quotient groups.

(b) Isomorphism theorems on groups.

(c) Classification of groups of order ≤ 7.

(d) External direct product of groups, order of an element in a direct product, criterion for external product of finite cyclic groups to be cyclic.

References:

1. Joseph Gallian (1999). Contemporary Abstract Algebra, Narosa Publishing House
2. Dummit and Foote(2003). Abstract Algebra 3 edition,John Wiley and Sons, Inc.

Additional Reference:

1. Michael Artin (2011). Algebra, Second Edition, Pearson Prentice-Hall of India, New Delhi.
2. J. B. Fraleigh (2013).A First Course in Abstract Algebra, Third edition, Narosa, New Delhi.
3. I. N. Herstein(1975). Topics in Algebra, Second edition, Wiley Eastern Limited.
4. N. S. Gopalakrishnan(2015), University Algebra, Third Edition,New Age International (P) Limited.
5. P.B. Bhattacharya, S. K. Jain and S. R. Nagpaul(1995). Basic Abstract Algebra, Second edition, Foundation Books, New Delhi.

Course Code	Course Title	Number of Lectures	No. of Credits
SMAT503	**METRIC SPACES-I**	**3**	**4**

Learning Objectives:

Up to this stage, learner do study the concepts of analysis which evidently rely on the notion of distance. In this course, the objective is to develop the usual idea of distance into an abstract form on any set of objects, maintaining its inherent characteristics, and the resulting consequences.

Learning Out Comes:

This course will enable the students tolearn:

- Various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.
- Analyse how a theory advances from a particular frame to a general frame.
- Appreciate the mathematical understanding of various geometrical concepts, viz. open balls or closed balls etc.in an abstract setting.
- Learn about the important topological properties, namely complete metric spaces.
- This course can help students to pursue research in Mathematics.

Unit I	Basic Concepts	15 L

(a) Definition of metric spaces with examples (more emphasis on $\mathbb{R}^n$).

(b) Open balls, Open sets, Examples and basic results. Hausdorff property.

(c) Subspace of a metric space and product of metric spaces.

(d) Limit point of a set, Isolated points, Interior of a set, Derived set, Examples and basic results.

(e) Equivalent metrics. Distance of a point from a set, distance between sets, diameter of a set in a metric space and bounded sets.

Unit II	Closed sets and Sequences	15 L

(a) Closed balls in metric spaces, Closed set-definition, examples.

(b) A closed set contains all its limit points, Closure of a set and boundary.

(c) Sequences in metric space, Convergence sequence in a metric space.

(d) Cauchy sequence in a metric space, sub-sequences, examples of convergent and Cauchy sequence with different metrics.

(e) Characterization of limit points and closure points in terms of sequences.

Unit III	**Complete Metric Spaces**	**15 L**

(a) Dense subsets in a metric space.

(b) Definition of complete metric spaces, with emphasis on $\mathbb{R}^n$.

(c) Completeness property in subspaces.

(d) Nested Interval theorem in $\mathbb{R}$ Cantor's Intersection Theorem.

References:

1. Shirali, Satish & Vasudeva, H. L. (2009). Metric Spaces, Springer, First Indian Print.
2. Pawan K. Jain, Khalil Ahmad(2004). Metric Spaces (2nd ed.), Narosa Publishing House.

Additional Reference:

1. Kumaresan, S. (2011). Topology of Metric Spaces (2nd ed.). Narosa Publishing House. New Delhi.
2. B. K. Tyagi (2010). First Course in Metric Spaces, Cambridge University Press
3. Rudin. W. (1976). Principles of Mathematical Analysis**,** McGraw-Hill Book Company.
4. Apostol, T. M. (2002) Mathematical Analysis, Narosa Publishing House.

Course Code	Course Title	Number of Lectures	No. of Credits
SMAT504	DATA ANALYTICS -III	3	4

Learning Objectives:

- The learner is able to develop relevant **programming** abilit ies.
- The learner is able to demonstrate proficiency with **analysis of data**.
- The learner is able to develop the ability to build and assess data - based **models**.
- The learner is able to demonstrate proficiency with analysis of data with open source **software** .
- The learner is able to demonstrate skill in **data management**.

Learning Out Comes:

Upon completing this course, students should be able to:

- Identify, collect, and clean a complex real-world dataset.
- Implement and evaluate commonly used supervised and unsupervised learning techniques, and clearly explain how these techniques work.
- Perform data cleaning and machine learning techniques in R (and Python, as necessary) in a robust and reproducible manner.
- Assess and articulate ethical and other concerns and limitations associated with using specific datasets for supervised and unsupervised learning.

Unit I	Introduction to Data Analytics	15L

(a) Operational and Decision Support System, Data-Information-Knowledge-Decision making-Action cycle. Basic definitions- Data Mining; Data warehousing and Data Marts, Knowledge Discovery in Databases: KDD process model, Principles of dimensional modelling, OLAP and OLTP, Data cubes, Data cube operations.

(b) Data Pre-processing: Cleaning: Missing Values; Noisy Values; Inconsistent values; redundant values. Outliers, Integration, transformation, reduction, Discretization: Equal Width Binning; Equal Depth Binning, Normalization, Smoothing.

Unit II	Supervised and Unsupervised Learning	15 L

(a) Supervised Learning: Distance based Algorithm, Rule base and tree based classifiers (revisited), Statistical based classifiers: Bayesian classification, Document classification, Bayesian Networks, Markov Networks, Regression/model trees: CHAID (Chi Squared Automatic Interaction Detector). CART (Classification And Regression Tree).

(b) Unsupervised Learning: Distance/Similarity, Partitioning Algorithm: K-Means; K-Medoids, Partitioning Algorithm for large data set: CLARA; CLARANS, Hierarchical Algorithms: Agglomerative (AGNES); Divisive (DIANA), Density based clustering: DBSCAN.

Unit III	Support Vector Machines, Principle Component Analysis	15 L

Basic idea of linear Support Vector Machines, linear Support Vector Machines formulation, matrix formulation of linear Support Vector Machines, Non-linear classifier assuming complete separation, Introduction to Kernel trick, Principal Components Analysis.

References:

1. Dunham, Margaret H, Data Mining: Introductory and Advanced Topics, Prentice Hall.
2. Witten, Ian and Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques, Second Edition, Morgan Kaufmann.
(http://www-bcf.usc.edu/~gareth/ISL/ISLR%20First%20Printing.pdf)

Additional Reference:

1. Han and Kamber (2006), Data Mining: Concepts and Techniques, Second Edition, Morgan Kaufmann
2. Berry and Linoff (2004), Data Mining Techniques, Second Edition, Wiley.
3. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani.(2017). An Introduction to Statistical Learning: With Applications in R, Springer.
4. John M. Chambers (2008). Software for Data Analysis: Programming with R (Statistics and Computing Springer)

Course Code	Course Title	Number of Lectures	Number of Credits
SMAT505AC	**Python and R Programming**	**4**	**2.5**

Learning Objectives:

- The objective of this course is to introduce various concepts of programming to the students using Python and R.

Learning outcomes:

After taking the course, students will be able to:

- Develop Python Programs on their own,
- Apply problem solving skills and implement any real world problems,
- Use R for statistical programming, computation, graphics, and modelling,
- Write functions and use R in an efficient way,
- Fit some basic types of statistical models.

Unit I	Introduction to Python	15 L

(a) Reasons for Python as the learner are first programming language. Introduction to the IDLE interpreter (shell) and its documentation.

(b) **Building Blocks of Program:** Data, Data Types, Data Binding, Variables, Constants, Declaration, Operations on Data such as assignment, arithmetic, relational, logical operations, dry run, and variables used.

(c) **Develop Code using Python:** Features, basic syntax, Writing and executing simple program, Basic Data Types such as numbers, strings, etc Declaring variables, Performing assignments, arithmetic operations, Simple input-output.

Unit II	Loops and Controls	15 L

(a) **Sequence Control:** Precedence of operators, Type conversion

(b) **Conditional Statements:** if, if-else, nested if –else

(c) **Looping:** for, while, nested loops

(d) **Control statements:** Terminating loops, skipping specific conditions

(e) **Collection Manipulation:** declaring strings, string functions, Lists, Tuples.

Unit III	Introduction to R programming	15 L

(a) R introduction, Installing R and RStudio, RStudio Overview, Working in the Console Arithmetic Operators, Logical Operations, Using Functions, Creating Variables.

(b) **Five basic classes:** Character, Numeric (Real Numbers) ,Integer (Whole Numbers) , Complex, Logical (True / False)

(c) **R Data Structures:** RVectors, R Matrix, R List, R Data Frame, R Factor

(d) **R flow Control:** if statement, **looping:** for, repeat, while – writing functions, function arguments and options

(e) **R Functions:** R Programming Function, Function Return Value, R Environment and Scope, R Recursive Function.

(f) R libraries

Unit IV	Graphics and Standard statistical models in R	15 L

(a) R Programming Bar Plot, R Programming Histogram, R Programming Pie Chart, R Programming Box Plot, R Programming Plot Function, R Programming Color, R Programming 3D Plot.

(b) **Descriptive statistics:** Measures of central tendency, Measures of variability, Correlation.

References:

1. Beginning Python: From Novice to Professional, Magnus Lie Hetland, Apress,2nd edition.
2. Paul Gries, et al.Practical Programming (2014) :An Introduction to Computer Science Using Python, 2nd Edition , Pragmatic Bookshelf.
3. Kenneth A Lambert (2018) : Fundamentals of Python First programs , Second Edition, Cengage Learning.
4. Beginning Python(2008): From Novice to Professional, Magnus Lie Hetland, Second Edition, Apress.
5. Wickham, H. &Grolemund, G. (2018). for Data Science. O'Reilly: New York. Available for free at http://r4ds.had.co.nz
6. Paul Tetor: R Cook Book, O'Reilly, http://www.bagualu.net/wordpress/wp-content/uploads/2015/10/R_Cookbook.pdf
7. R for Dummies; 2 edition

(2015)http://sgpwe.izt.uam.mx/files/users/uami/gma/R_for_dummies.pdf

Additional Reference:

1. Charles Dierbach (2013). Introduction to Computer Science using Python, Wiley.
2. Paul Gries , Jennifer Campbell, Jason Montojo,(2014). Practical Programming: An Introduction to Computer Science Using Python 3, 2nd Edition , Pragmatic Bookshelf.
3. Garrett Grolemund (2014): Hands-On Programming with R, O'Reilly
4. Mark Gardener(2012): Beginning R: The Statistical Programming Language, Wrox

Course Code	Course Title	Number of Practicals	Number of Credits
SMAT501PR	**Practical-I** **(Based on SMAT 501 and SMAT 502)**	**6**	**4**
Sr. No.	**List of Practical Experiments on Integral Calculus**		
1.	Evaluation of double and triple integral		
2.	Evaluate integrals using Change of variable.		
3.	Problem based on Line integrals of scalar and vector fields.		
4.	Using Green's theorem, evaluate integrals.		
5.	Examples on Surface integrals.		
6.	Using Stoke's and Guass' divergence theorem, evaluate integrals.		
Sr. No,	**List of Practical Experiments on Abstract Algebra -II**		
1.	Examples on Groups and subgroups		
2.	Examples on Cyclic subgroups		
3.	Examples on Permutation groups		
4.	Examples on Homomorphism and isomorphism of groups		
5.	Examples on Normal subgroups and quotient groups		
6.	Examples on Direct product of groups		

Course Code	Course Title	Number of Practicals	Number of Credits
SMAT502PR	**Practical-II (Based on SMAT 503 and SMAT 504)**	**6**	**4**
Sr. No.	**Suggested List of Practical Experiments on Metric Spaces- -I**		
1.	Examples on Metric spaces and subspaces		
2.	Examples on Open sets, Interior point, Interior of a set in a metric spaces.		
3.	Problems on Limit point and Derived set in a metric spaces.		
4.	Examples on Closed set, Closure of a set, boundary of a set, diameter of a set, distance of a point from a set, distance between two sets.		
5.	Problems on convergent sequences, dense sets, Cauchy sequence, subsequences in metric spaces.		
6.	Problems on complete metric spaces		
Sr. No.	**Suggested List of Practical Experiments on Data Analytics-III**		
1.	Create tables using different applications. Develop an application to create dimension tables in a cube and form star schema and snowflake schema.		
2.	Develop an application to pre-process data imported from external sources.		
3.	Pre-process the given data set and hence apply clustering techniques like K- Means, K-Medoids. Interpret the result.		
4.	Pre-process the given data set and hence apply partition clustering algorithms. Interpret the result		
5.	Pre-process the given data set and hence classify the resultant data set using tree classification techniques and Statistical based classifiers. Interpret the result.		
6.	**(a)** Pre-process the given data set and hence classify the resultant data set using support vector machine. Interpret the result . **(b)** Write a program to explain different functions of Principal Components.		
Note: The experiments for Data Analytics-III may be done using software/tools like Hadoop WEKA/ R / Python/ etc.			

Course Code	Course Title	Number of Practical's	Number of Credits
SMAT501ACPR	**Practical-III (Based on SMAT 505AC)**	**4**	**2.5**
Sr. No.	**Suggested List of Practical Experiments on**		
1.	Programs based on I/O concepts.		
2.	Programs based on Control Statement.		
3.	Programs based on Strings, Tuples and lists.		
4.	Programs based on R data structures, R Control flow		
5.	Programs based on R functions		
6.	Programs based on R graphics and Descriptive statistics:		

MODALITY OF ASSESSMENT

Theory Examination Pattern:

(A) Continuous Assessment CA) - 40% :

Total Marks: 40

- **(a) CA-I:**Class Test containing (multiple choice questions / objective type questions): 20 Marks
- **(b) CA-II:** Assignment/Project based on Mathematical Software's like SciLab, SageMath etc. : 20 marks

(B) Semester End Examination (SEE) - 60 %

Total Marks:60

Duration - 2 hours duration.

Paper Pattern:

(a) There shall be 4 questions each of 20 marks. On each unit, there will be one question.
(b) All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions on
Q.(1)(A)	Any 1 out of 2	08	Unit I
Q.(1)(B)	Any 2 out of 4	12	
Q.(2)(A)	Any 1 out of 2	08	Unit II
Q.(2)(B)	Any 2 out of 4	12	
Q.(3)(A)	Any 1 out of 2	08	Unit III
Q.(3)(B)	Any 2 out of 4	12	

Practical Examination Pattern (For SMAT501PR , SMAT502PR)

Total Marks: 50for SMAT501PR and 50 for SMAT502PR

(A) Practical-CA: Test (Definitions/ Fill in the blanks / Match the columns/ True or False etc.) **:** 15Marks

(B) Practical-SEE:Test(Solving 3 out of 4 problems) : 30 Marks

(C) Practical Book/ Journal: 5 Marks

- The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.
- In case of loss of Journal and/or Report, a Lost Certificate should be obtained from Headof the department; failing which the student will not be allowed to appear for the practical examination.

Practical Examination Pattern: (For SMAT501ACPR)

Total Marks: 100

Duration: 3 Hours

Paper Pattern:

(A) Total evaluation is of 80 marks based on experiments mentioned in the list of SMAT501ACPR

Questions	Options	Marks	Questions on
Q.(1)	Any 2 out of 3	40	Unit I and II
Q.(2)	Any 2 out of 3	40	Unit IIIand IV

(B) Certified Journal: 10 Marks and **Viva Voce:** 10 marks based on the experiments done in the Journal

- The questions to be asked in the practical examination shall be from the list of practical experiments mentioned in the practical topics .A few modifications in the experiments may be expected during the examination.
- The semester end practical examination on the machine will be of **THREE** hours.
- Students should carry a certified Journal with minimum of 05 practical's(mentioned in the practical topics)at the time of examination.

- Number of students per batch for the regular practical should not exceed 20. Not more than two students are allowed to do practical experiment on one computer at a time.
- 2 practical's each of 2 lecture periods per week per batch. Two lecture periods of the practical's shall be conducted in succession together on a single day.

Passing Criteria:

To pass each course

- A Student has to acquire minimum of 10 marks out of 40 marks in CA and 21 marks out of 60 marks in SEE in each Theory course. Besides this a student has to acquire minimum of 40 marks out of 100 marks in each Theory course.
- A student has to acquire minimum of 40 marks in each Practical course.