NATIONAL EDUCATION POLICY 2020 INITIATIVES

A REPORT ON MODEL CURRICULUM CONTENTS FOR

B.A./B.Sc. (Hons) Mathematics,
B.A./B.Sc. with Mathematics as a Major/Minor Subject
&
M.A./M.Sc. Mathematics (One Year)

KARNATAKA STATE HIGHER EDUCATION COUNCIL

Department of PG Studies and Research in Mathematics,

Kuvempu University, Shankaraghatta,

Karnataka - 577451

2021

Preamble

The subject wise expert committee to draft model curriculum contents in Mathematics constituted by the Department of Higher Education, Government of Karnataka, Bangalore vide GO No. ED 260 UNE 2019 (PART-1) DATED 13.08.2021 is pleased to submit its partial report on the syllabus for the First Year (First & Second Semesters) B.A./B.Sc.(Basic/Honors) Mathematics and detailed Course Structure for B.A./B.Sc.(Honors) Mathematics and M.Sc. (One Year) Mathematics.

The committee discussed various models suggested by the Karnataka State Higher Education Council in its joint meetings with the Chairpersons of Board of Studies of all state universities in Karnataka and resolved to adopt Model IIA (*Model Program Structure for the Bachelor of Arts (Basic/Hons.)/ Bachelor of Science (Basic/Hons.*) for the subjects with practical's with Mathematics as Major/Minor.

To achieve the core objectives of the National Education Policy 2020 it is unanimously resolved to introduce computer based practical's for the Discipline Core (DSC) courses by using Free and Open Source Software's (FOSS) tools for implementation of theory based on DSC courses as it is also suggested by the LOCF committee that the papers may be taught using various Computer Algebra System (CAS) software's such as Mathematica, MATLAB, Maxima and R to strengthen the conceptual understanding and widen up the horizon of students' self-experience. In view of these observations the subject expert committee suggested the software's Phython /R/ Maxima/ Scilab/ Maple/ MATLAB /Mathematica for hands on experience of implementation of mathematical concepts in computer based lab.

The expert committee suggests the implementation this curriculum structure in all the Departments of Mathematics in Universities/Colleges in Karnataka.

The subject expert committee designed the Course Learning Outcome (CO) to help the learners to understand the main objectives of studying the courses by keeping in mind of the Programme outcomes (PO) of the graduate degree with honors in Mathematics or a graduate degree with Mathematics as a major subject.

As the Mathematics subject is a vast with several branches of specializations, it is difficult for every student to learn each branch of Mathematics, even though each paper has its own importance. Hence the subject expert committee suggests number of elective papers (for both Discipline electives and Open Electives) along with Discipline Core Courses. The BoS in Mathematics of universities may include additional electives based on the expertise of their staff and needs of the students'. A student can select elective paper as per her/his needs and interest.

The subject expert committee in Mathematics suggests that the concerned Department/Autonomous Colleges/Universities to encourage their faculty members to include necessary topics in addition to courses suggested by the expert committee.

Composition of Subject Expert Committee in Mathematic

1.	Dr. N. B. Naduvinamani Professor, Department of Mathematics Gulbarga University, Kalaburagi.	Chairperson
2.	Dr. Soner Nandappa D. Professor, Department of Mathematics University of Mysore, Mysore.	Member
3.	Dr. P.M.Patil Professor, Department of Mathematics Karnatak University, Dharwad.	Member
4.	Dr. H. G. Nagaraj Professor, Department of Mathematics Bangalore University, Bangalore.	Member
5.	Dr. Narasimhamurthy S. K. Professor, Department of Mathematics Kuvempu University, Shimoga.	Member
6.	Dr. Patil Mallikarjun Professor, Department of Mathematics Tumkur University, Tumakuru.	Member
7.	Dr. U. S. Mahabaleshwar Professor, Department of Mathematics Davangere University, Davangere.	Member
8.	Dr. K.V. Prasad Professor, Department of Mathematics VSK University, Bellary.	Member
9.	Dr. (Smt.) V. S. Shigehalli Professor, Department of Mathematics Rani Channamma University, Belagavi.	Member
10.	Sri. Sanjay Kumar Pattankar Associate Professor, Nrupatunga University, Bangalore.	Member
11.	Dr. Christopher Associate Professor, Kittle College, Dharwad.	Member
12.	Dr. Rajesh Kanna M. R. Associate Professor, Sri D. Devaraj Urs GFGC, Hunasur.	Member
13.	Smt. Geeta S. Walikar Associate Professor, GFGC, Kumta.	Member
14.	Dr.Venkatesh Kulkarni Associate Professor, NV Degree College, Kalaburagi.	Member
15.	Dr. Tejaswini Bi. Yakkundimath Special Officer, KSHEC, Bangalore.	Member Convener

Name of the Degree Program : B.A./B.Sc.
Discipline Course : Mathematics
Starting Year of Implementation : 2021-22

Programme Outcomes (PO): By the end of the program the students will be able to:

PO 1	**Disciplinary Knowledge**: Bachelor degree in Mathematics is the culmination of in-depth knowledge of Algebra, Calculus, Geometry, differential equations and several other branches of pure and applied mathematics. This also leads to study the related areas such as computer science and other allied subjects.
PO 2	**Communication Skills**: Ability to communicate various mathematical concepts effectively using examples and their geometrical visualization. The skills and knowledge gained in this program will lead to the proficiency in analytical reasoning which can be used for modeling and solving of real life problems.
PO 3	**Critical thinking and analytical reasoning:** The students undergoing this programme acquire ability of critical thinking and logical reasoning and capability of recognizing and distinguishing the various aspects of real life problems.
PO 4	**Problem Solving** : The Mathematical knowledge gained by the students through this programme develop an ability to analyze the problems, identify and define appropriate computing requirements for its solutions. This programme enhances students overall development and also equip them with mathematical modeling ability, problem solving skills.
PO 5	**Research related skills:** The completing this programme develop the capability of inquiring about appropriate questions relating to the Mathematical concepts in different areas of Mathematics.
PO 6	**Information/digital Literacy**: The completion of this programme will enable the learner to use appropriate softwares to solve system of algebraic equation and differential equations.
PO 7	**Self - directed learning**: The student completing this program will develop an ability of working independently and to make an in-depth study of various notions of Mathematics.
PO 8	**Moral and ethical awareness/reasoning:** The student completing this program will develop an ability to identify unethical behavior such as fabrication, falsification or misinterpretation of data and adopting objectives, unbiased and truthful actions in all aspects of life in general and Mathematical studies in particular.
PO 9	**Lifelong learning**: This programme provides self directed learning and lifelong learning skills. This programme helps the learner to think independently and develop algorithms and computational skills for solving real word problems.
PO 10	Ability to pursue advanced studies and research in pure and applied Mathematical sciences.

Assessment

Weightage for the Assessments (in percentage)

Type of Course	Formative Assessment/ I.A.	Summative Assessment (S.A.)
Theory	40%	60 %
Practical	40%	60 %
Projects	40 %	60 %
Experiential Learning (Internship etc.)	--	--

Contents of Courses for B.A./B.Sc. with Mathematics as Major Subject & B.A./B.Sc. (Hons) Mathematics
Model IIA

Semester	Course No.	Theory/ Practical	Credits	Paper Title	Marks	
					S.A.	I.A.
I	MATDSCT1.1	Theory	4	Algebra - I and Calculus - I	60	40
	MATDSCP1.1	Practical	2	Theory based Practical's on Algebra - I and Calculus - I	30	20
	MATOET1.1	Theory	3	(A) Basic Mathematics - I (B) Business Mathematics - I (C) Competitive Mathematics - I (D) Mathematical Modelling - I	60	40
II	MATDSCT2.1	Theory	4	Algebra - II and Calculus - II	60	40
	MATDSCP2.1	Practical	2	Theory based Practical's on Algebra - II and Calculus - II	30	20
	MATOET2.1	Theory	3	(A) Basic Mathematics – II (B) Business Mathematics - II (C) Competitive Mathematics - II (D) Mathematical Modelling - II	60	40
Exit Option with Certificate						
III	MATDSCT3.1	Theory	4	Ordinary Differential Equations and Real Analysis-I	60	40
	MATDSCP3.1	Practical	2	Theory based Practical's on Ordinary Differential Equations and Real Analysis-I	30	20
	MATOET3.1	Theory	3	(A) Ordinary Differential Equations (B) Quantitative Mathematics	60	40
IV	MATDSCT4.1	Theory	4	Partial Differential Equations and Integral Transforms	60	40
	MATDSCP4.1	Practical	2	Theory based Practical's on Partial Differential Equations and Integral Transforms	30	20
	MATOET4.1	Theory	3	(A) Partial Differential Equations (B) Mathematical Finance	60	40
Exit Option with Diploma						
V	MATDSCT5.1	Theory	3	Real Analysis and Complex Analysis	60	40
	MATDSCP5.1	Practical	2	Theory based Practical's on Real Analysis and Complex Analysis	30	20
	MATDSCT5.2	Theory	3	Ring Theory	60	40
	MATDSCP5.2	Practical	2	Theory based Practical's on Ring Theory	30	20

	MATDSET5.1	Theory	3	(A) Vector Calculus (B) Mechanics (C) Mathematical Logic	60	40
VI	MATDSCT6.1	Theory	3	Linear Algebra	60	40
	MATDSCP6.1	Practical	2	Theory based Practical's on Linear Algebra	30	20
	MATDSCT6.2	Theory	3	Numerical Analysis	60	40
	MATDSCP6.2	Practical	2	Theory based Practical's on Numerical Analysis	30	20
	MATDSET6.1	Theory	3	(A) Analytical Geometry in 3D (B) Number Theory (C) Special Functions (D) History of Bhârtîya Ganita	60	40
Exit Option with Bachelor of Arts, B.A./ Bachelor of Science, B.Sc. Degree						
VII	MATDSCT7.1	Theory	3	Discrete Mathematics	60	40
	MATDSCP7.1	Practical	2	Theory based Practical's on Discrete Mathematics	30	20
	MATDSCT7.2	Theory	3	Advanced Ordinary Differential Equations	60	40
	MATDSCP7.2	Practical	2	Theory based Practical's on Advanced Ordinary Differential Equations	30	20
	MATDSCT7.3	Theory	4	Advanced Analysis	60	40
	MATDSET 7.1	Theory	3	(A) Graph Theory (B) Entire and Meromorphic Functions (C) General Topology (D) Bhâratîya Trikoṇmiti Śâstra	60	40
	MATDSET 7.2	Theory	3	Research Methodology in Mathematics	60	40
	MATDSCT8.1	Theory	4	Advanced Complex Analysis	60	40
	MATDSCT8.2	Theory	4	Advanced Partial Differential	60	40
VIII				Equations		
	MATDSCT8.3	Theory	3	Fuzzy Sets and Fuzzy Systems	60	40
	MATDSET 8.1	Theory	3	(A) Operations Research (B) Lattice theory and Boolean Algebra (C) Mathematical Modelling (D) *Ankapâśa* (Combinatorics)	60	40

	MATDSET 8.2	Research Project	6 (3+ 3)	Research Project*	120	80
				OR	OR	OR
				Any Two of the following electives		
				(A) Finite Element Methods	60	40
				(B) Cryptography	60	40
				(C) Information Theory and Coding		
				(D) Graph Theory and Networking		

Award of Bachelor of Arts Honours, B.A. (Hons)/ Bachelor of Science Honours, B.Sc.(Hons) Degree in Mathematics

One Year M.A./M.Sc. degree in Mathematics (Two Semesters)

Semester	Course Number	Theory/ Practical	Credits	Title of the Course	S.A.	I.A.
I	PGMATDSCT1.1	Theory	3	C++ Programming for Mathematics	60	40
	PGMATDSCP1.1	Practical	2	Computer Practical's on C++ Programming for Mathematics	30	20
	PGMATDSCT1.2	Theory	3	Computational Numerical Methods	60	40
	PGMATDSCP1.2	Practical	2	Computer Practical's on CNM	30	20
	PGMATDSCT1.3	Theory	4	Functional Analysis	60	40
	PGMATDSET1.1	Theory	3	(A) Fluid Mechanics – I (B) Computational Fluid Mechanics (C) Contact Geometry (D) Fuzzy Topology (E) Ramanujan Theta Function and Continued Fractions	60	40
	PGMATDSET1.2	Theory	3	(A) Advanced Graph Theory (B) Partition Theory (C) Algebraic Number Theory (D) Riemannian Geometry	60	40
II	PGMATDSCT2.1	Theory	4	Measure Theory	60	40
	PGMATDSCT2.2	Theory	4	Differential Geometry	60	40
	PGMATDSCT2.3	Theory	3	Mathematical Methods	60	40
	PGMATDSET2.1	Theory	3	(A) Fluid Mechanics – II (B) Magnetohydrodynamics (C) Finsler Geometry and Relativity (D) Mathematical Modelling	60	40
	PGMATDSET2.2	Project	6	Research Project	120	80

- In lieu of the research Project, two additional elective papers/ Internship may be offered

Abbreviation for MATDSCT1.1 /MATDSCP1.1

MAT – Mathematics; DSC – Discipline Core; T – Theory/ P – Practical; 1 – First Semester; .1 – Course 1

PGMATDSCT1.1: PG- Post Graduate; MAT- Mathematics; DSC- Discipline Core; T- Theory 1 – First Semester; .1 – Course 1

CURRICULUM STRUCTURE FOR UNDERGRADUATE DEGREE PROGRAM

Name of the Degree Program : B.A. / B.Sc. (Honors)

Discipline/Subject : Mathematics

Starting Year of Implementation: 2021-22

PROGRAM ARTICULATION MATRIX

Semester	Course No.	Programme Outcomes that the Course Addresses	Pre-Requisite Course (s)	Pedagogy*	Assessment**
I	MATDSCT1.1	PO 1, PO 2, PO 3	-----	MOOC	CLASS TESTS
II	MATDSCT2.1	PO 1, PO 2, PO 3, PO 8	MATDSCT1.1	PROBLEM SOLVING	SEMINAR
III	MATDSCT3.1	PO 1, PO 4, PO 7, PO 8	-----	SEMINAR	QUIZ
IV	MATDSCT4.1	PO 1, PO 4, PO7, PO 8	MATDSCT3.1	PROJECT BASED LEARNING	ASSIGNMENT
V	MATDSCT5.1	PO 1, PO 2, PO 3, PO 5	----		
V	MATDSCT5.2	PO 3, PO 4, PO 7, PO 10	MATDSCT2.1	ASSIGNMENTS	
VI	MATDSCT6.1	PO 6, PO 7, PO 10.	MATDSCT5.2	GROUP DISCUSSION	
VI	MATDSCT6.2	PO 3, PO 4, PO 5, PO 8, PO 9, PO 10.	MATDSCT1.1 & MATDSCT2.1		TERM END EXAM
VII	MATDSCT7.1	PO 3, PO 4, PO 5, PO 7, PO 9.	MATDSCT1.1 & MATDSCT2.1		
VII	MATDSCT7.2	PO 2, PO 4, PO 5, PO 10	MATDSCT3.1		
VII	MATDSCT7.3	PO 2, PO 4, PO 5, PO 10	MATDSCT3.1		
VIII	MATDSCT8.1	PO 2, PO 4, PO 5, PO 10	MATDSCT5.1		
VIII	MATDSCT8.2	PO 2, PO 4, PO 5, PO 10	MATDSCT4.1		VIVA-VOCE
VIII	MATDSCT8.3	PO 2, PO 4, PO 5, PO 10	MATDSCT7.3		

** Pedagogy for student engagement is predominantly Lecture. However, other pedagogies enhancing better student engagement to be recommended for each course. This list includes active learning/ course projects / Problem based or Project based Learning / Case Studies / Self Study like Seminar, Term Paper or MOOC.

*** Every Course needs to include assessment for higher order thinking skills (Applying/ / Evaluating / Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e. assessment for Learning).

B.A./B.Sc. with Mathematics as a Minor in the 3rd Year

Semester	Course No.	Theory/ Practical	Credits	Paper Title	Marks	
					S.A.	I.A.
V	MATDSCMT5.1	Theory	3	Complex Analysis	60	40
	MATDSCMP5.1	Practical	2	Theory based Practical's on Complex Analysis	30	20
VI	MATDSCMT6.1	Theory	3	Numerical Analysis	60	40
	MATDSCMP6.1	Practical	2	Theory based Practical's on Numerical Analysis	30	20

Abbreviation for MATDSCMT5.1 / MATDSCMP5.1
MAT – Mathematics; **DSC** – Discipline Core; **M** – Minor; **T** – Theory /**P** – Practical; **5** – Fifth Semester; **.1** – Course 1

Credit Distribution for B.A./B.Sc.(Honors) with Mathematics as Major in the 3rd Year

(For Model IIA)

Subject	Semester	Major/ Minor in the 3rd Year	Credits					
			Discipline Specific Core (DSC)	Open Elective (OE)	Discipline Specific Elective (DSE)	AECC & Languages	Skill Enhancement Courses (SEC)	Total Credits
Mathematics	I - IV	Major	4 Courses (4+2)x 4=24	4 Courses 3 x 4 = 12	---	(4+4=8) Courses 8x(3+1)= 32	2 Courses 2x(1+1)= 4	72
Other Subject		Minor	24	--	--	--	--	24
								96
Mathematics	V & VI	Major	4 Courses 4x(3+2)=20	-----	2 Courses 2 x 3 = 06	---	2 Courses 2 x 2 = 4	30
Other Subject		Minor	10	--	--	--	--	10
				(96+40)**=136**				
Mathematics	VII & VIII	Major	2 Courses 2x(3+2)=10 3 Courses 3 x 4 = 12 1 Course 1 x 3 = 3 Total=25	-----	2 Courses 2 x 3 = 6 Res.Meth 1 x 3 = 3 2 Courses 2 x 3 = 6 Total= 20	----	-----	40
Total No. of Courses			14	04	07	08	04	
								136+40**=176**

Syllabus for B.A./B.Sc. with Mathematics as Major Subject & B.A./B.Sc. (Hons) Mathematics

SEMESTER – I

MATDSCT 1.1: Algebra - I and Calculus - I	
Teaching Hours : 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 56 Hours	**Max. Marks: 100 (S.A.-60 + I.A. – 40)**

Course Learning Outcomes: This course will enable the students to

- Learn to solve system of linear equations.
- Solve the system of homogeneous and non homogeneous linear of *m* equations in *n* variables by using concept of rank of matrix, finding Eigen values and Eigen vectors.
- Sketch curves in Cartesian, polar and pedal equations.
- Students will be familiar with the techniques of integration and differentiation of function with real variables.
- Identify and apply the intermediate value theorems and L'Hospital rule.

Unit-I: Matrix: Recapitulation of Symmetric and Skew Symmetric matrices, Cayley- Hamilton theorem, inverse of matrices by Cayley-Hamilton theorem (Without Proof). Algebra of Matrices; Row and column reduction to Echelon form. Rank of a matrix; Inverse of a matrix by elementary operations; Solution of system of linear equations; Criteria for existence of non-trivial solutions of homogeneous system of linear equations. Solution of non-homogeneous system of linear equations. Eigen values and Eigen vectors of square matrices, real symmetric matrices and their properties, reduction of such matrices to diagonal form,

14 Hours

Unit-II: Polar Co-ordinates: Polar coordinates, angle between the radius vector and tangent. Angle of intersection of two curves (polar forms), length of perpendicular from pole to the tangent, pedal equations. Derivative of an arc in Cartesian, parametric and polar forms, curvature of plane curve-radius of curvature formula in Cartesian, parametric and polar and pedal forms- center of curvature, asymptotes, evolutes and envelops. **14 Hours**

Unit-III: Differential Calculus-I: Limits, Continuity, Differentiability and properties. Properties of continuous functions. Intermediate value theorem, Rolle's Theorem, Lagrange's Mean Value theorem, Cauchy's Mean value theorem and examples. Taylor's theorem, Maclaurin's series, Indeterminate forms and evaluation of limits using L'Hospital rule. **14 Hours**

Unit-IV: Successive Differentiation: nth Derivatives of Standard functions $e^{ax+b}, (ax+b)^n, \log(ax+b), \sin(ax+b), \cos(ax+b), e^{ax}\sin(bx+c)$,

$e^{ax}\cos(bx+c)$, Leibnitz theorem and its applications. Tracing of curves (standard curves) **14 Hours**

Reference Books:

1. University Algebra - N S Gopala Krishnan, New Age International (P) Limited.
2. Theory of Matrices - B S Vatsa, New Age International Publishers.
3. Matrices - A R Vasista, Krishna Prakashana Mandir.
4. Differential Calculus - Shanti Narayan, S. Chand & Company, New Delhi.
5. Applications of Calculus, Debasish Sengupta, Books and Allied (P) Ltd., 2019.
6. Calculus – Lipman Bers, Holt, Rinehart & Winston.
7. Calculus - S Narayanan & T K Manicavachogam Pillay, S Viswanathan Pvt. Ltd., vol. I & II.
8. Schaum's Outline of Calculus - Frank Ayres and Elliott Mendelson, 5th ed. USA: Mc. Graw.

MATDSCP 1.1: Practical's on Algebra - I and Calculus – I	
Practical Hours : 4 Hours/Week	**Credits: 2**
Total Practical Hours: 56 Hours	**Max. Marks: 50** **(S.A.-30 + I.A. – 20)**

Course Learning Outcomes: This course will enable the students to

- Learn *Free and Open Source Software (FOSS)* tools for computer programming.
- Solve problem on algebra and calculus theory studied in **MATDSCT 1.1** by using FOSS softwares.
- Acquire knowledge of applications of algebra and calculus through FOSS.

Practical/Lab Work to be performed in Computer Lab (FOSS)

Suggested Softwares: Maxima/Scilab/Maple/MatLab/Mathematica/Python/R.

Introduction to the software and commands related to the topic.

1. Computation of addition and subtraction of matrices.
2. Computation of Multiplication of matrices.
3. Computation of Trace and Transpose of Matrix.
4. Computation of Rank of matrix and Row reduced Echelon form.
5. Computation of Inverse of a Matrix using Cayley-Hamilton theorem.
6. Solving the system of homogeneous and non-homogeneous linear algebraic equations.
7. Finding the nth Derivative of e^{ax}, trigonometric and hyperbolic functions.
8. Finding the nth Derivative of algebraic and logarithmic functions.
9. Finding the nth Derivative of $e^{ax}\sin(bx+c)$, $e^{ax}\cos(bx+c)$.

10. Finding the Taylor's and Maclaurin's expansions of the given functions.
11. Finding the angle between the radius vector and tangent.
12. Finding the curvatures of the given curves.
13. Tracing of standard curves.

Open Elective Course

(For students of Science stream who have not chosen Mathematics as one of Core subjects)

MATOET 1.1: Basic Mathematics - I	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100** **(S.A.-60 + I.A. – 40)**

Course Learning Outcomes: This course will enable the students to

- Learn to solve system of linear equations.
- Solve the system of homogeneous and non homogeneous m linear equations by using the concept of rank of matrix, finding Eigen values and Eigen vectors.
- Students will be familiar with the techniques of differentiation of function with real variables.
- Identify and apply the intermediate value theorems and L'Hospital rule.
- Learn to trace some standard curves.

Unit-I: Matrices: Recapitulation of Symmetric and Skew Symmetric matrices, Cayley- Hamilton theorem, inverse of matrices by Cayley-Hamilton theorem (Without Proof). Algebra of Matrices; Row and column reduction, Echelon form. Rank of a matrix; Inverse of a matrix by elementary operations; Solution of system of linear equations; Criteria for existence of non-trivial solutions of homogeneous system of linear equations. Solution of non-homogeneous system of linear equations. Eigen values and Eigen vectors of square matrices, real symmetric matrices and their properties, reduction of such matrices to diagonal form.

14 Hours

Unit-II: Differential Calculus: Limits, Continuity, Differentiability and properties. Intermediate value theorem, Rolle's Theorem , Lagrange's Mean Value theorem, Cauchy's Mean value theorem and examples. Taylor's theorem, Maclaurian's series, Indeterminate forms and examples. **14 Hours**

Unit-III: Successive Differentiation: nth Derivatives of Standard functions $e^{ax+b}, (ax+b)^n, \log(ax+b), \sin(ax+b), \cos(ax+b), e^{ax}\sin(bx+c)$, $e^{ax}\cos(bx+c)$, Leibnitz theorem and its applications. Tracing of curves (standard curves) **14 Hours**

Reference Books:

1. University Algebra - N.S. Gopala Krishnan, New Age International (P) Limited
2. Theory of Matrices - B. S. Vatsa, New Age International Publishers.
3. Matrices – A. R. Vasista, Krishna Prakashana Mandir.
4. Applications of Calculus, Debasish Sengupta, Books and Allied (P) Ltd., 2019.
5. Differential Calculus - Shanti Narayan, S. Chand & Company, New Delhi.
6. Calculus – Lipman Bers, Holt, Rinehart & Winston.
7. Calculus – S. Narayanan & T. K. Manicavachogam Pillay, S. Viswanathan Pvt. Ltd., vol. I & II.
8. Schaum's Outline of Calculus - Frank Ayres and Elliott Mendelson, 5th ed. USA: Mc. Graw.

Open Elective

(For Students of other than Science Stream)

MATOE 1.1(B): Business Mathematics-I	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100 (S.A.- 60 + I.A. – 40)**

Course Learning Outcomes: This course will enable the students to

- Translate the real word problems through appropriate mathematical modelling.
- Explain the concepts and use equations, formulae and mathematical expression and relationship in a variety of context.
- Finding the extreme values of functions.
- Analyze and demonstrate the mathematical skill require in mathematically intensive areas in economics and business.

Unit-I: Algebra – Set theory and simple applications of Venn Diagram, relations, functions, indices, logarithms, permutations and combinations. Examples on commercial mathematics.

14 Hours

Unit - II: Matrices: Definition of a matrix; types of matrices; algebra of matrices. Properties of determinants; calculations of values of determinants upto third order; Adjoint of a matrix, elementary row and column operations; solution of a system of linear equations having unique solution and involving not more than three variables. Examples on commercial mathematics.

14 Hours

Unit - III: **Differential Calculus**: Constant and variables, functions, Limits &

continuity. Differentiability and Differentiation, partial differentiation, rates as a measure, maxima, minima, Partial Derivatives up to second order; Homogeneity of functions and Euler's Theorem; Total Differentials; Differentiation of implicit function with the help of total differentials, Maxima and Minima; cases of one variable involving second or higher order derivatives; Cases of two variables involving not more than one constraint.

14 Hours

Reference Books:

1. Basic Mathematics, Allel R.G.A, Macmillan, New Delhi.
2. Mathematics for Economics, Dowling, E.T. , Schaum's Series, McGraw Hill, London.
3. Quantitative Techniques in Management, Vohra, N.D., Tata McGraw Hill, New Delhi.
4. Business Mathematics, Soni R.S., Pitamber Publishing House, Delhi

Open Elective: MATOE 1.1(C): Competitive Mathematics-I:

MATOE 1.1(C): Competitive Mathematics-I	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100** **(S.A.- 60 + I.A. – 40)**

UNIT-I: Series: NUMBER SERIES: Number series tests present numerical sequences that follow a logical rule which is based on elementary arithmetic. An initial sequence is given from which the rule is to be deduced, predict the next number that obeys the rule. ALPHABET SERIES: Under this series letter will be coded or arranged in some pattern, normally based on the position of the letters. CONTINUOUS PATTERN SERIES: These types of questions usually consist of a series of small letters of the small letters which follow a certain pattern. However, some letters are missing from the series. These missing letters are then given in a proper sequence as of alternatives. **14 Hours**

UNIT-II: Alphabet Test: ALPHABETICAL ORDER: Arranging words in alphabetical order implies to arrange them in the order as they appear in a dictionary that is as per the order in which the beginning letters of the words appear in the English alphabet. ALPHABETICAL QUIBBLE: In this type of questions generally a letter series is given, be it the English alphabets from A to Z or a randomized sequence of letters. The candidate is then required to trace the letters satisfying certain given conditions as regard their position in the given sequence or the sequence obtained by performing certain given operations on the given sequence. **14 Hours**

UNIT-III: Coding and Decoding: CODE is 'a system of signals'. Coding is, therefore a method of transmitting a message between sender and receiver which cannot be understood or comprehended by a third person. The coding - decoding test is set up to judge a candidates ability to decipher to particular word/message and break the court to decipher the message. In coding, actual alphabet/words/terms/numbers are replaced by certain other alphabets/ words/number/symbols etc. according to a certain rule to solve this type of questions we have to detect the rule and then answer the questions. Decoding is the method to find the meaning of something that has written in code. **14 Hours**

UNIT-IV: Numbers and Ranking: Number test: In this type of question, generally a set, group or series of numeral is given and the candidate is required to find how many times a number satisfies the conditions specified in the question occurs. Ranking test: Generally, a number of questions are arranged in either ascending or descending order of their performance in a certain activity. **14 Hours**

References:

1. Quantitative aptitude for competitive exam, R.S .Aggarwal exam series 2020 book by Dr.R.S .Aggarwal and Abhijit Guha.
2. Quantitative Aptitude Quantum for CAT, II Edition, PHI Learning Pvt. Ltd. Delhi, by Abhijit Guha.
3. GMAT Volume 1 and 2, Ignus Power Education Publication
4. Faster Track Objective Arithmetic (Revised Edition), Arihant Publications by Rajesh Verma

Open Elective: MATOE 1.1(D): Mathematical Modelling-I:

MATOE 1.1(D): - Mathematical Modelling I	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100** **(S.A.- 60 + I.A. – 40)**

Unit-I: Mathematical Modelling: Need, Techniques, Classification and Simple Illustrations, Simple Situations Requiring Mathematical Modelling. The Technique of Mathematical Modelling. Classification of Mathematical Models. Some Characteristics of Mathematical Models. **14 Hours**

Unit-II: Mathematical Modelling: Need, Techniques, Classification and Simple Illustrations: Mathematical Modelling through Geometry. Mathematical Modelling

through Algebra. Mathematical Modelling through Trigonometry. Mathematical Modelling through Calculus. **14 Hours**

Unit-III: Mathematical Modelling Through Ordinary Differential Equations of First Order: Mathematical Modelling through Differential Equations, Effect of Immigration and emigration on population size, Linear Growth and Decay Models, Non-Linear Growth and Decay Models. **14 Hours**

Unit 4: Mathematical Modelling Through Ordinary Differential Equations of First Order: Compartment Models, Mathematical Modelling in Dynamics through Ordinary Differential Equations of First Order, Mathematical Modelling of Geometrical Problems through Ordinary Differential Equations of First Order. **14 Hours**

References:

1. Mathematical Modelling - J. N. Kapur, New Age International Private Limited.
2. An Introduction to Mathematical Modelling - Edward A Bender published, Dover Books on Computer Science
3. Mathematical Modelling with Case Studies: Using Maple and MATLAB, Third edition -B. Barnes, G.R. Fulford, CRC Press, Taylor and Francis Group
4. An Introduction to Mathematical Modelling by Michael Alder HeavenForBooks.com

SEMESTER – II

MATDSCT 2.1: Algebra - II and Calculus - II	
Teaching Hours : 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 56 Hours	**Max. Marks: 100 (S.A.-60 + I.A. – 40)**

Course Learning Outcomes: This course will enable the students 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.
- Understand the concept of differentiation and fundamental theorems in differentiation and various rules.
- Find the extreme values of functions of two variables.

Unit-I: Real Number System: Recapitulation of number system. Countable and uncountable sets, standard theorems. Real line, bounded sets, supremum and infimum of a set, completeness properties of R, Archimedean property of R. Intervals, neighborhood of a point, open sets, closed sets, limit points and Bolzano-Weierstrass theorem (Without proof)

14 hours

Unit-II: Groups: Definition of a group with examples and properties, congruence, problems. Subgroups, center of groups, order of an element of a group and its related theorems, cyclic groups, Coset decomposition, Factor groups, Lagrange's theorem and its consequences. Fermat's theorem and Euler's ϕ function. **14 hours**

Unit-III: Partial Derivatives: Functions of two or more variables-explicit and implicit functions, partial derivatives. Homogeneous functions- Euler's theorem, total derivatives, differentiation of implicit and composite functions, Jacobians and standard properties and illustrative examples. Taylor's and Maclaurin's series for functions of two variables, Maxima-Minima of functions of two variables.

14 hours

Unit-IV: Integral Calculus: Recapitulation of definite integrals and its properties. *Line integral*: Definition of line integral and basic properties, examples on evaluation of line integrals. *Double integral*: Definition of Double integrals and its conversion to iterated integrals. Evaluation of double integrals by changing the order of integration and change of variables. Computation of plane surface areas,

volume underneath a surface of revolution using double integral. *Triple integral*: Definition of triple integrals and evaluation-change of variables, volume as triple integral. Differentiation under the integral sign by Leibnitz rule.

14 hours

Reference Books:

1. Topics in Algebra, I N Herstein, Wiley Eastern Ltd., New Delhi.
2. Higher algebra, Bernard & Child, Arihant, ISBN: 9300943199/ 9789300943199.
3. Modern Algebra, Sharma and Vasista, Krishna Prakashan Mandir, Meerut, U.P.
4. Differential Calculus, Shanti Narayan, S. Chand & Company, New Delhi.
5. Integral Calculus, Shanti Narayan and P K Mittal, S. Chand and Co. Pvt. Ltd.,
6. Schaum's Outline Series, Frank Ayres and Elliott Mendelson, 5th ed. USA: Mc. Graw Hill., 2008.
7. Mathematical Analysis, S C Malik, Wiley Eastern.
8. A Course in Abstract Algebra, Vijay K Khanna and S K Bhambri, Vikas Publications.
9. Text Book of B.Sc. Mathematics, G K Ranganath, S Chand & Company.

PRACTICAL

MATDSCP 2.1: On Algebra -II and Calculus - II	
Practical Hours : 4 Hours/Week	**Credits: 2**
Total Practical Hours: 56 Hours	**Max. Marks: 50 (S.A.-30 + I.A. – 20)**

Course Learning Outcomes: This course will enable the students to

- Learn *Free and Open Source Software (FOSS)* tools for computer programming
- Solve problem on algebra and calculus by using FOSS software's.
- Acquire knowledge of applications of algebra and calculus through FOSS

Practical/Lab Work to be performed in Computer Lab

Suggested Software's: Maxima/Scilab/Maple/MatLab/Mathematica/Python/R.

1. Program for verification of binary operations.
2. Program to construct Cayley's table and test Abelian for given finite set.
3. Program to find all possible cosets of the given finite group.
4. Program to find generators and corresponding possible subgroups of a cyclic group.

5. Programs to verification of Lagrange's theorem with suitable examples.
6. Program to verify the Euler's ϕ function for a given finite group.
7. Program to verify the Euler's theorem and its extension.
8. Programs to construct series using Maclaurin's expansion for functions of two variables.
9. Program to evaluate the line integrals with constant and variable limits.
10. Program to evaluate the Double integrals with constant and variable limits.
11. Program to evaluate the Triple integrals with constant and variable limits.
12. Program to evaluate volume using triple integral.

Open Elective

(For students of Science stream who have not chosen Mathematics as one of the Core subjects)

MATOET 2.1(A): Basic Mathematics – II	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100 (S.A.- 60 + I.A. – 40)**

Course Learning Outcomes: This course will enable the students 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.
- Understand the concept of differentiation and fundamental theorems in differentiation and various rules.
- Find the extreme values of functions of two variables.
- To understand the concepts of multiple integrals and their applications.

Unit-I: Groups: Definition of a group with examples and properties, congruence, problems. Subgroups, center of groups, order of an element of a group and its related theorems, cyclic groups, Coset decomposition, Factor groups, Lagrange's theorem and its consequences. Fermat's theorem and Euler's ϕ function. **14 hours**

Unit-II: Partial Derivatives: Functions of two or more variables-explicit and implicit functions, partial derivatives. Homogeneous functions- Euler's theorem, total derivatives, differentiation of implicit and composite functions, Jacobians and standard properties and illustrative examples. Taylor's and Maclaurin's series for functions of two variables, Maxima-Minima of functions of two variables. **14 hours**

Unit-III: Integral Calculus: Recapitulation of definite integrals and its properties. *Line integral*: Definition of line integral and basic properties, examples on evaluation of line integrals. *Double integral*: Definition of Double integrals and its conversion to iterated integrals. Evaluation of double integrals by changing the order of integration and change of variables. Computation of plane surface areas, volume underneath a surface of revolution using double integral. *Triple integral*: Definition of triple integrals and evaluation-change of variables, volume as triple integral. Differentiation under the integral sign by Leibnitz rule.

14 hours

Reference Books:

1. Topics in Algebra, I N Herstein, 2nd Edition, Wiley Eastern Ltd., New Delhi.
2. Higher algebra, Bernard & Child, Arihant Pub.
3. Modern Algebra, Sharma and Vasishta, Krishna Prakashan Mandir, Meerut, U.P.
4. A Course in Abstract Algebra, Vijay K Khanna and S K Bhambri, Vikas Publications.
5. Differential Calculus, Shanti Narayan, S. Chand & Company, New Delhi.
6. Integral Calculus, Shanti Narayan and P K Mittal, S. Chand and Co. Pvt. Ltd.,
7. Schaum's Outline Series, Frank Ayres and Elliott Mendelson, 5th ed. USA: McGraw Hill., 2008.
8. Mathematical Analysis, S C Malik, Wiley Eastern.
9. Text Book of B.Sc. Mathematics, G K Ranganath, S Chand & Company.

Open Elective

(For Students of other than science stream)

MATOET 2.1(B): Business Mathematics-II	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100 (S.A.- 60 + I.A. –40)**

Course Learning Outcomes: This course will enable the students to

- Integrate concept in international business concept with functioning of global trade.
- Evaluate the legal, social and economic environment of business.
- Apply decision-support tools to business decision making.
- Will be able to apply knowledge of business concepts and functions in an integrated manner.

Unit - I: Commercial Arithmetic: Interest**:** Concept of Present value and Future value, Simple interest, Compound interest, Nominal and Effective rate of interest, Examples and Problems Annuity: Ordinary Annuity, Sinking Fund, Annuity due, Present Value and Future Value of Annuity, Equated Monthly Installments (EMI) by Interest of Reducing Balance and Flat Interest methods, Examples and Problems. **14 Hours**

Unit - II: Measures of central Tendency and Dispersion: Frequency distribution: Raw data, attributes and variables, Classification of data, frequency distribution, cumulative frequency distribution, Histogram and give curves. Requisites of ideal measures of central tendency, Arithmetic Mean, Median and Mode for ungrouped and grouped data. Combined mean, Merits and demerits of measures of central tendency, Geometric mean: definition, merits and demerits, Harmonic mean: definition, merits and demerits, Choice of A.M., G.M. and H.M. Concept of dispersion, Measures of dispersion: Range, Variance, Standard deviation (SD) for grouped and ungrouped data, combined SD, Measures of relative dispersion: Coefficient of range, coefficient of variation. Examples and problems.

14 Hours

Unit - III: Correlation and regression: Concept and types of correlation, Scatter diagram, Interpretation with respect to magnitude and direction of relationship. Karl Pearson's coefficient of correlation for ungrouped data. Spearman's rank correlation coefficient. (with tie and without tie) Concept of regression, Lines of regression for ungrouped data, predictions using lines of regression. Regression coefficients and their properties (without proof). Examples and problems.

14 Hours

Reference Books:

1. Practical Business Mathematics, S. A. Bari New Literature Publishing Company New Delhi
2. Mathematics for Commerce, K. Selvakumar Notion Press Chennai
3. Business Mathematics with Applications, Dinesh Khattar & S. R. Arora S. Chand Publishing New Delhi
4. Business Mathematics and Statistics, N.G. Das &Dr. J.K. Das McGraw Hill New Delhi
5. Fundamentals of Business Mathematics, M. K. Bhowal, Asian Books Pvt. Ltd New Delhi
6. Mathematics for Economics and Finance: Methods and Modelling, Martin Anthony and Norman, Biggs Cambridge University Press Cambridge

7. Financial Mathematics and its Applications, Ahmad Nazri Wahidudin Ventus Publishing APS Denmark
8. Fundamentals of Mathematical Statistics, Gupta S. C. and Kapoor V. K.:, Sultan Chand and Sons, New Delhi.
9. Statistical Methods, Gupta S. P.: Sultan Chand and Sons, New Delhi.
10. Applied Statistics, Mukhopadhya Parimal New Central Book Agency Pvt. Ltd. Calcutta.
11. Fundamentals of Statistics, Goon A. M., Gupta, M. K. and Dasgupta, B. World Press Calcutta.
12. Fundamentals of Applied Statistics, Gupta S. C. and Kapoor V. K.:, Sultan Chand and Sons, New Delhi.

Open Elective: MATOE 2.1(C): Competitive Mathematics-II (Other than science stream students)

MATOET 2.1(C): Competitive Mathematics-II	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100 (S.A.- 60 + I.A. – 40)**

UNIT-I: Mathematical Operations: Questions on simple mathematical operations. There are four fundamental operations, namely: addition $(+)$, subtraction $(-)$, multiplication $(\times)$ and division $(\div)$. There are also statements less than $(<)$, greater than $(>)$, equal to $(=)$, not equal to $(\neq)$ etc. Such operations are represented by symbols different from the usual ones. The candidates have to make the substitution of the real signs and solve the equations accordingly. While attempting to solve a mathematical expression, proceed according to the rule BODMAS – that is brackets of division multiplication addition and subtraction. We can perform addition and subtraction in any order.

Unit-II: Direction Sense Test: There are four directions such as north, south, east, and west. There are four regions (i) north-east (ii) north-west (iii) south-east (iv) south-west. Based on these directions problems have to perform with different mathematical techniques.

Unit-III-Time and Clock: Find the day of the week on a given data for this use the concept odd days, ordinary year and leap year. For a given time find the degree made by the hands of clock.

Unit-IV: Inserting the missing character: This includes type of questions, a figure, a set of figures, the arrangement of the matrix in given, each of which bears certain characters, be it numbers, letters or a group/combination of letters/numbers; following a certain pattern. It is required to decipher the pattern and accordingly find the missing

character in the figure.

References:

1. Quantiative aptitude for competative exam, R.S .Aggarwal exam series 2020 book by Dr.R.S .Aggarwal and Abhijit Guha.
2. Quantitative Aptitude Quantum for CAT, II Edition, PHI Learning Pvt Ltd. Delhi, by Abhijit Guha.
3. GMAT Volume 1 and 2, Ignus Power Education Publication
4. Faster Track Objective Arithmatic (Revised Edition), Arihant Publications by Rajesh Verma

Open Elective: MATOE 2.1(D): Mathematical Modelling-II:

MATOET 2.1(D): Mathematical Modelling -II	
Teaching Hours : 3 Hours/Week	**Credits: 3**
Total Teaching Hours: 42 Hours	**Max. Marks: 100** **(S.A.- 60 + I.A. – 40)**

Unit-I: Mathematical Modelling through Systems of Ordinary Differential Equations of First Order: Mathematical Modelling in Population Dynamics, Mathematical Modelling of Epidemics through Systems of Ordinary Differential Equations of First Order, Compartment Models through Systems of Ordinary Differential Equations

Unit-II: Mathematical Modelling through Systems of Ordinary Differential Equations of First Order: Mathematical Modelling in Economics through Systems of Ordinary Differential Equations of First Order.

Unit-III: Mathematical Models in Medicine, Arms Race, Battles and International Trade in Terms of Systems of Ordinary Differential Equations.

Unit-IV: Mathematical Modelling in Dynamics through Systems of Ordinary Differential Equations of First Order.

References:

1. Mathematical Modeling Models, Analysis and Applications by Sandip Banerjee, published by CRC Press, Taylor and Francis Group.
2. Mathematical Modeling Techniques - Rutherford Aris, Dover Publications.
3. Mathematical Analysis for Modeling- Judah Rosenblatt, Stoughton Bell, CRC Press, Taylor and Francis Group.