Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum for F. Y. B. Sc. Mathematics

With effect from June 2019

Program Educational Objectives (PEOs) for B.Sc Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of an graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioural skills needed for successful social adaptation , work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependentlyand also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields.Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	Program Specific Outcomes (PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic Competence:** (i) Articulate basic concepts such as limit, continuity, differentiability of real valued and vector valued functions of one and several variables along with the concepts of linear dependence, eigenvalues, eigen vectors. (ii) Apply different methods to solve the differential equations. (iii) Unify structures in Mathematics such as sets, relations and functions, logical structure, relationships among them and explore the more complex structures such as groups, rings and vector spaces.
PSO2	**Personal and Professional Competence:** (i) Apply mathematical problems and solutions in variety of contexts related to science, technology, business and industry, and illustrate these solutions using symbolic, numeric, or graphical methods. (ii) Analyse the data by selecting and using appropriate mathematical formulae or techniques in order to draw the relevant conclusion. (iii) Create proficiency in writing mathematical proofs.
PSO3	**Research Competence:** (i) Apply advanced knowledge on topics in pure mathematics, empowering the students to pursue higher education at reputed academic institutions. Impart analytic and thinking skills to develop initiatives and innovative ideas for R&D in various fields. (ii) Integrate the knowledge of Mathematics to solve problems in different branches of sciences. (iii) Create, select, adapt and apply appropriate techniques and modern computing tools for complex computing activities.
PSO4	**Entrepreneurial and Social Competence:** (i) Employ analytical skills acquired helps to get distinguishing employment opportunities in several fields including IT, Research and Development Department and Teaching field. (ii) Gain awareness about issues related to plagiarism and ethical issues related to protection of intellectual property are copyrights, trademarks and patents.

Programme Structure

Year	Course Code	Course Title	Credits
F.Y. B. Sc.	**Semester I**		
	MTS1101	Calculus-I	2
	MTS1102	Algebra	2
	MTS1103	Mathematics Practical-I	2
	Semester II		
	MTS1201	Calculus-II	2
	MTS1202	Geometry	2
	MTS1203	Mathematics Practical-II	2

Particulars	Name of Paper	Paper Code	Title of Paper	No. of Credits
S.Y. B.Sc.	**Semester III**			
	Theory Paper - 1	MTS 2301	Calculus of Several Variables	2
	Theory Paper – 2(A)	MTS 2302	Ordinary Differential Equations	2
	Theory Paper – 2(B)	MTS 2303	Numerical Analysis	2
	Practical Paper - 1	MTS 2304	Practical-III (based on Paper I and II)	2
	Semester IV			
	Theory Paper - 3	MTS 2401	Linear Algebra	2
	Theory Paper – 4A	MTS 2402	Vector Calculus	2
	Theory Paper – 4B	MTS 2403	Laplace and Fourier Transforms	2
	Practical Paper - 2	MTS 2404	Practical-IV (based on Paper I and II)	2

Year	Paper No.	Course code	Title	Credits	CE Maximum Marks	ESE Maximum Marks	Total Maximum Marks
T. Y. B. Sc.	**Semester V**						
	DSE-1A	MTS3501	Real Analysis-I	2	50	50	100
	DSE-1B	MTS 3502	Complex Analysis-I	2	50	50	100
	DSE-2A	MTS 3503	Group Theory	2	50	50	100
	DSE-2B	MTS 3504	Advanced Linear Algebra	2	50	50	100
	DSE-3A	MTS 3505	Metric Spaces-I	2	50	50	100
	DSE-3B	MTS 3506	Number Theory	2	50	50	100
	DSE-1	MTS 3507	Mathematics Practical –I based on MTS3501 & MTS3502	2	50	50	100
	DSE-2	MTS 3508	Mathematics Practical –II based on MTS3503 & MTS3504	2	50	50	100
	DSE-3	MTS 3509	Mathematics Practical –III based on Paper SEC	2	50	50	100
	SEC-1*	MTS 3511	Operations Research	2	50	50	100
	SEC-2*	MTS 3512	Financial Mathematics-I	2	50	50	100
	SEC-3*	MTS 3513	Python Programming	2	50	50	100
	SEC-4*	MTS 3514	Partial Differential Equations	2	50	50	100
	SEC-5*	MTS 3515	Combinatorics	2	50	50	100

Year	Paper No.	Course code	Title	Credits	CE Maximum Marks	ESE Maximum Marks	Total Maximum Marks
T.Y. B.Sc.	**Semester VI**						
	DSE-4A	MTS 3601	Real Analysis-II	2	50	50	100
	DSE-4B	MTS 3602	Complex Analysis-II	2	50	50	100
	DSE-5A	MTS 3603	Ring Theory	2	50	50	100
	DSE-5B	MTS 3604	Dynamical Systems	2	50	50	100
	DSE-6A	MTS 3605	Metric Spaces-II	2	50	50	100
	DSE-6B	MTS 3606	Differential Geometry	2	50	50	100
	DSE-4	MTS 3607	Mathematics Practical –IV based on MTS3601 & MTS3602	2	50	50	100
	DSE-5	MTS 3608	Mathematics Practical –V based on MTS3603 & MTS3604	2	50	50	100
	DSE-6	MTS 3609	Mathematics Practical –VI based on Paper SEC	2	50	50	100
	SEC-6*	MTS 3611	Optimization Techniques	2	50	50	100
	SEC-7*	MTS 3612	Financial Mathematics-II	2	50	50	100
	SEC-8*	MTS 3613	Graph Theory	2	50	50	100
	SEC-9*	MTS 3614	Lebesgue Integration	2	50	50	100
	SEC-10*	MTS 3615	Mathematical Models in Population Biology	2	50	50	100

F.Y. B.Sc. Semester I		
Title of the Course and Course Code	**Calculus-I MTS 1101**	**Number of Credits : 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Outline basic concepts of real numbers and define sequences and series of real numbers.
CO2	Interpret inequalities like Geometric Mean-Arithmetic Mean inequality, Bernoulli's inequality.
CO3	Apply properties of Real numbers and implement different tests for checking convergence of series.
CO4	Explain and apply the statements of different theorems for checking convergence and divergence of sequences and series.
CO5	Evaluate limit of a sequence and decide whether given sequence is convergent, divergent, bounded, monotone or Cauchy.
CO6	Create counter examples and support the theory with applicable examples to understand the real analysis.

Unit No.	**Title of Unit and Contents**
I	**Real Numbers:** Algebraic and Order properties of Real numbers, Solution set of inequalities, Geometric Mean-Arithmetic Mean inequality, Bernoulli's inequality, Absolute Value of real numbers, Triangle inequality and its applications, Bounded set, Supremum (l.u.b.), Infimum (g.l.b.), Completeness property of real numbers, Archimedean property of R, Density of rational numbers in R, Intervals of real line, nested interval property (statement only).
II	**Sequences of Real Numbers:** Definition of a sequence, Limit of a sequence, Uniqueness of limit, Bounded sequence, Tail of a sequence, Algebra of limits of sequences, Squeeze theorem for sequences, Ratio test for sequences, Monotone sequence, Monotone convergence theorem (Statement only), Subsequences, Divergence Criteria, Monotone subsequence theorem (statement only), Bolzano-Weierstrass theorem (statement only), Cauchy sequence (definition and examples only).
III	**Series of Real Numbers:** Definition, Sequence of partial sums, Convergent series and Divergent series, n-th tem test, Ratio test and root tests for convergence of series (statements and examples only).

References:

1. Robert G. Bartle, Donald R. Sherbert, Introduction to Real Analysis: John Wiley & Sons, Fourth Edition, 2011.
2. Tom M. Apostol Calculus Volume-I, Wiley International Edition, 2007.
3. M. Spivak, Calculus, Cambridge, 2006.
4. J. Stewart, Calculus, Cengage Learning, 2012.
5. G.B. Thomas, R. Finney, Calculus and Analytic Geometry, Addison-Wesley, 1995.

Suggested Reading:

1. Who Gave You the Epsilon? Cauchy and the Origins of Rigorous Calculus Judith V. GrabinerThe American Mathematical Monthly, March 1983, Volume 90, Number 3, pp. 185–194.

Title of the Course and Course Code	Algebra MTS 1102	Number of Credits : 02
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall basic concepts in sets, relations and functions.	
CO2	Interpret properties of complex numbers and polynomials.	
CO3	Apply different principles and theorems for understanding, and solving problems on integers and complex numbers.	
CO4	Explain the geometric concepts of algebraic properties of two complex numbers. Evaluate Division Algorithms and G.C.D. for polynomials.	
CO5	Evaluate theory of complex numbers and problems on integers and complex numbers.	
CO6	Create counter examples and support the theory of equivalence relation, equivalence classes, partition to illustrate that every partition gives an equivalence relation and vice-versa.	

Unit No.	Title of Unit and Contents
I	Principle of Mathematical Induction: Well ordering principle for N, Principle of Mathematical induction, Strong form ofPrinciple of Mathematical induction.
II	**Sets, Relation and Functions:** Power set, Operation on sets, Cartesian product of sets Definition of function, Domain, co-domain and the range of function, injective, surjective and bijective functions, composite function, invertible function Definition of relation, equivalence relation, equivalence classes, Definition of partition, every partition gives an equivalence relation and vice-versa.
III	**Complex Numbers:** Addition and multiplication of complex numbers, Modulus and amplitude of a complex number, Real and imaginary parts and conjugate of a complex number. Geometric representation sum, differences, product and quotient of two complex numbers as well as modulus, amplitude and the conjugate of a complex number. De-Moivre'sTheorem,roots of unity, Euler's Formula.
IV	**Polynomials:** The set Q[x] of polynomials in one variable with rational coefficients. Division Algorithm (without proof). G.C.D of two polynomials (without proof). Remainder Theorem, Factor Theorem (with proof). Relation between the roots and the coefficients of a polynomial.

References:

Include Reference Books/ e-resources/ journals/any other learning material

1. Barbeau, Edward J, Polynomials, Springer, 1989
2. Brown and Churchill, Complex Variables and Applications, 7th Edition, McGraw Hill, 2010.

Title of the Course and Course Code	Mathematics Practical I MTS1103	Number of Credits : 02
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Recall and interpret various mathematical definitions of sequences, series, real numbers, functions, relations, polynomials, complex numbers.	
CO2	Illustrate different concepts of functions, relations, polynomials.	
CO3	Interpret and differentiate between various types of functions. Apply equivalence relations on sets and corresponding equivalence classes.	
CO4	Explain different methods for finding the roots of a given equation and acquire the knowledge of the relationship between coefficients and roots of an equation.	
CO5	Determine whether the given sequence and series is convergent or not.	
CO6	Create intuition-forming examples or counter examples and prove Conjectures in sequences and series.	

Unit No.	Title of Unit and Contents
I	**Different Methods of Proofs:** Proof by Induction, Proof by contradiction
II	**Sets, Relations and Functions:** Examples of bijections between N and Z, Equivalence relations on Integers, Miscellaneous problems.
III	**Integers** Division algorithm and GCD, Congruence modulo m
IV	Cardan's method
V	Ferrari's method
VI	Real Numbers and properties
VII	Sequences of real numbers
VIII	Problems on convergent sequences
IX	Series of real numbers
X	Different tests for convergence of series

F.Y. B.Sc. Semester II		
Title of the Course and Course Code	**Calculus-II MTS 1201**	**Number of Credits : 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Outline and recall basic concepts of real numbers, sequences and series.
CO2	Interpret properties of continuous and differentiable functions.
CO3	Apply different principles, tests and theorems for solving problems on limit, continuity, differentiation and different aspects of real analysis.
CO4	Analyze and examine different principles, tests and theorems on different aspects of real analysis.
CO5	Evaluate n-th ordered derivatives of functions.
CO6	Create counter examples and support the theory with applicable examples to illustrate the Fundamental Theorem of Calculus.

Unit No.	**Title of Unit and Contents**
I	**Limits of functions**: Cluster point, Definition of limit, Limits of some standard functions, Sequential criteria for limits, Uniqueness of limit, Divergence criteria, Algebra of limits, Squeeze theorem for limit.
II	**Continuous functions:** Definition, Sequential criteria and examples, Composition of continuous functions, Continuous functions on intervals, Boundedness theorem (statement only), Maximum-Minimum theorem (statement only), Location of roots theorem (statement only), Intermediate value theorem, Fixed point theorem, Preservation of intervals theorem.
III	**Derivative:** Definition, Differentiability imply continuity, Non differentiable functions, Algebra of differentiable functions, Caratheodory's theorem, Chain rule for derivative of composite function, Derivative of inverse function.
IV	**Mean value theorems:** Vanishing of the derivative at interior extremum, Rolle's Theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Applications of mean value theorems to geometric properties of functions, First derivative test for extrema, Second derivative test for extrema, Derivative test for convexity, Intermediate value property for derivative, Darboux's theorem.
V	**Successive differentiation:** n-th derivative of some standard functions, Leibnitz's theorem for n^{th} derivative, Applications of Leibnitz's theorem. Indeterminate forms, L' Hospital's Rule, Taylor's theorem, Maclaurin's theorem, Applications of Taylor's Theorem.

References:

1. Robert G. Bartle, Donald R. Sherbert, Introduction to Real Analysis: John Wiley & Sons, Fourth Edition, 2011.
2. Tom M. Apostol Calculus Volume-I, Wiley International Edition, 2007.
3. M. Spivak, Calculus, Cambridge, 2006.
4. J. Stewart, Calculus, Cengage Learning, 2012.
5. G.B. Thomas, R. Finney, Calculus and Analytic Geometry, Addison-Wesley, 1995.

Title of the Course and Course Code	Geometry MTS 1202	Number of Credits : 02
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall basic concepts in school geometry.	
CO2	Interpret geometrical ideas like line, plane, sphere in purely algebraic manner. Explain properties of change of axes, translation of axis, rotation of axes and rectangular Cartesian coordinates of a point in plane.	
CO3	Apply removal of xy term and linear terms to reduce given conics to its standard form. Use the condition of tangency to get equation of Tangent plane.	
CO4	Explain and analyze the concepts in conic sections and spheres.	
CO5	Evaluate different concepts in lines and planes. Test whether given plane passes through the three points. Determine the length of the perpendicular from a point to a plane.	
CO6	Create counter examples and support the theory with applicable examples to articulate different conditions in the coplanar lines.	

Unit No.	Title of Unit and Contents
I	**Analytical geometry of two dimensions:** Locus of points, Change of Axes: Translation of Axis and Rotation of axes. Removal of *xy* term and linear terms, General Equation of second degree in *x* and *y*. Centre of Conic, Reduction to Standard form: length of Axes, equation of axes, Co-ordinates of foci, Eccentricity, vertex, Equation of directrix and latus rectum
II	**Planes in Three Dimension** Rectangular Cartesian co-ordinates of a point in Plane, Orientation of Axes Co-ordinates of a point, Direction Angles, Direction Ratios, Direction Cosines, Direction ratios of a line joining two points, Relation between direction ratios and direction cosines, Angle between two lines, General Equation of first degree, Normal form of the equation of a plane, Transform to the normal form, Angle between two planes, Determination of a plane under given conditions, Plane passing through a given points, Plane passing through three points, System of planes, Two sides of planes, Length of the perpendicular from a point to a plane, Bisectors of angles between two planes, Joint equation of two planes
III	**Lines in Three Dimensions** Equation of line, Symmetrical form of the equation of a line, Equation of a line passing through two points, Transformation of the equation of a line from the asymmetric form to the symmetric form, Angle between a line and plane, Coplanar lines: Condition for a line to lie in a plane, condition for two lines to be coplanar. Sets of condition which determines a line: Number of arbitrary constants in the equations of a straight line, Sets of conditions which determine line, Skew lines and shortest distance: To find the length and the equation of the line of shortest distance between two lines, Length of the perpendicular from a point to a line.
IV	**Sphere** Equation of a sphere, sphere with a given diameter, Intercept form, Equation of the sphere through four points, Plane section of a sphere, Intersection of two spheres. Sphere through a given circle, Sphere passing through the circle intersection of the given sphere and plane, Sphere passing through a circle which is the intersection of two spheres, Intersection of a sphere and a line. Equation of Tangent plane: Standard equation of sphere. Equation of tangent plane, The condition of tangency.

References:

Include Reference Books/ e-resources/ journals/any other learning material

1. Shantinarayan: Analytical Solid Geometry, S. Chand and Company Ltd, New Delhi, 1998.
2. P.K.Jain and Khalil Ahmad, A Text Book of Analytical Geometry of Three Dimensions, Wiley
   Estern Ltd. 1999.
3. Askwyth, E. H: The Analytical Geometry of the Conic Sections.

Title of the Course and Course Code	Mathematics Practical-II MTS 1203	Number of Credits: 02
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall and interpret various mathematical definitions of limit, continuity, differentiation, planes, lines, spheres.	
CO2	Illustrate different concepts of limit, continuity, differentiation, planes, lines,	
CO3	Apply the properties of conics to solve problems in real life situations.	
CO4	Differentiate between various types of limits, continuity, differentiation.	
CO5	Evaluate limits, continuity, derivatives and nth derivatives of functions.	
CO6	Develop different techniques to find nth derivative of product of two functions.	

Unit No.	Title of Unit and Contents
I	Numerical Methods: Bisection method, Newton -Raphson method, Simson's 1/3 and 3/8 rule
II	System of Linear Equations: Gaussian Elimination, Cramer's rule
III	Line and Plane
IV	Sphere
V	Continuous functions
VI	L'Hospital rule
VII	Successive Differentiation
VIII	Taylor's theorem