# BOS in Mathematics Meeting Minutes of May 10, 2020

The online meeting of BOS in Mathematics meeting was held on May 10, 2020 by Online Mode on Google Meet platform at 10:00 am. Following members were present for the meeting.

1. Prof. Dr. Deore Rajendra
2. Prof.Dr. Thakkar Sarita
3. Dr. Naik Uday
4. Dr. Sapre Rajeev
5. Mr. Kshirsagar Dhananjay
6. Mr. Mohan Nitsure
7. Mr. Hiremath Channayya
8. Mrs. Gardi Sampada

The meeting commenced with the warm welcome of all the members of BOS by the BOS Chairman Hiremath.

Mr. Hiremath Channayya informed the members that earlier this meeting was scheduled on 21st March, 2020 but it was not possible to conduct the meeting in COVID 19 pandemic so it was cancelled. Mr. Hiremath informed about various activities of Mathematics Dept. in the academic year 2019-20.

**<u>To review and reframe the old syllabus of S. Y. B.Sc.</u>**

Mr. Hiremath reviewed the old syllabus of Mathematics Paper I, II and III of S.Y B.Sc. Dr. Rajendra Deore pointed out that the present syllabus of S.Y B.Sc. is quite ok in order to maintain the flow and continuity of F.Y.B.Sc. syllabus. Dr. Rajeev Sapre responded to Dr. Rajendra Deore. So, it was decided that no need to change the present syllabus. Dr. S.H. Thakkar suggested that practical can be taken with the help of any free and open-source software like Scilab. Everyone agreed for the same. So, it is decided that conduct practical with the help of software.

**<u>Resolution:</u>** It is unanimously resolved that the changes modified in the old syllabus were accepted.

Proposed by Dr. Channayya Hiremath                Seconded by Dr. Dr. Rajendra Deore

Annexure I: Draft of new syllabus.

**<u>Discussion on the Internal Evaluation System</u>**

Mr. C. N. Hiremath, Chairman of the BOS in Mathematics informed about the existing evaluation process and semester pattern as per the University instructions/ ordinances. Based on the recommendations given by the examination committee, Mr. C. N. Hiremath informed that let the semester pattern be continued and evaluation/ examination pattern for each subject/course be 70:30. Thirty marks will be allotted for the Continuous Internal Evaluation and 70 marks for the Semester End Examination. Thus, the nature for the Continuous Internal Evaluation system for 30 marks was decided as per the following:

| | |
|---|---|
| Class test | 10 Marks |
| Active Participation in the class | 10 Marks |
| Tutorials / Home assignments/<br>Problem solving Seminars /<br>Online Course Attendance / | 10 Marks |

**<u>Resolution</u>**: It is unanimously resolved that Internal Evaluation System was approved.

Proposed by Mr.Channayya Hiremath                Seconded by Dr. Rajeev Sapre

**<u>Discussion on Question paper pattern</u>**

The chairman of the BOS sighted into the external evaluation pattern also. He put forth the pattern of the external examination for 70 marks before the BOS as per the following:

a) There shall be FIVE questions. The first question $Q_1$ shall be of 10 objective type questions for 10 marks based on the entire syllabus. The next three questions $Q_2$, $Q_3$,$Q_4$ shall be of 15 marks, each based on the units I,II,III respectively. The fifth question $Q_5$ shall be of 15 marks based on the entire syllabus.

b) All the questions shall be compulsory. The questions$Q_2$, $Q_3$, $Q_4$, $Q_5$ shall have internal choices within the questions including the choices; Maximum marks with options shall be 30.

c) The questions Q2, Q3, Q4, Q5 may be subdivided in to sub-questions as a, b, c, d & e, etc. and the allocation of marks depends on the weightage of the topic. Also, chairman of the BOS sighted pattern of practical examination for each paper is as follows

| No. | Question Pattern | Marks |
|---|---|---|
| Q.1 | Short answer questions based on all syllabus | 20 |
| Q.2 | Long Answer Questions (based on all syllabus) | 15 |
| | Performance in Regular Practical's | 05 |
| | Viva | 05 |
| | Journal | 05 |
| Total | | 50 |

After discussion it was accepted by all members.

**Resolution**: It is unanimously resolved that question paper pattern was approved.

Proposed by Mrs. Gardi Sampada Seconded by Mr. Kshirsagar Dhananjay

**To prepare the panel of external examiners and paper setters**

Mrs. Gardi Sampada said that it is a need to prepare the panel of external paper setters, examiners and moderators for the FY and SY BSc Mathematics for the current academic year. It is decided that the selection will be based on the criteria of outside the vicinity. Rather the preference will be given to the persons belonging to the vicinity for the sake of convenience as the college resides in the utmost rural milieu.

**Resolution**: It is unanimously resolved that panel of external paper setters, examiners and moderators for the BSc. Mathematics was approved.

Proposed by Dr. Channayya Hiremath Seconded by Dr. Rajeev Sapre

Annexure II: Panel of examiners

Proposed by Dr. Channayya Hiremath Seconded by Mr. Vinayak Kedage

**To start skill-based certificate courses**

Dr. Rajeev Sapre recommended that Vedic Mathematics is our Indian mathematics which is very interesting and easy and helpful for the students who appear for competitive exam. Dr. Rajeev Sapre suggested certificate course on. After discussion certificate courses viz. Vedic Mathematics, Soft Skill Certificate course, R software certificate course, Sage math software was finalized.

It is resolved that among the above list at least two courses should be started from next academic year.

**Resolution**: It is unanimously resolved that skill-based certificate courses were accepted.

Proposed by Dr. Rajeev Sapre Seconded by Prof.Dr. Thakkar Sarita

**Any other relevant matter with the permission of chairperson**

No other proposal.

Dr. Hiremath said that all the matters on the agenda have been discussed thoughtfully and the good decisions have been taken. He also said at this happy moment I take a privilege to thank everyone present online for the BOS meeting and for fruitful discussions as well as their contribution in designing the syllabus.

The meeting was over at 11:00 am.

Annexure I
B. Sc. General (Semester Pattern) B. Sc. Second Year
MATHEMATICS – CURRICULUM

| Semester | Paper Code | Paper | Lectures /Practicals | Marks | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | External | Internal | Total | |
| Semester III | ASPUSMT301 | Theory Paper I Calculus III | 45 | 70 | 30 | 100 | 02 |
| | ASPUSMT302 | Theory Paper II Linear transformations and Matrices | 45 | 70 | 30 | 100 | 02 |
| | ASPUSMT303 | Theory Paper III Discrete Mathematics | 45 | 70 | 30 | 100 | 02 |
| | ASPUSMTP01 | Practical based on Paper I, II and III | 05 | 45 | 105 | 150 | 03 |
| Semester IV | ASPUSMT401 | Theory Paper I - Calculus IV | 45 | 70 | 30 | 100 | 02 |
| | ASPUSMT402 | Theory Paper II – Algebra III | 45 | 70 | 30 | 100 | 02 |
| | ASPUSMT403 | Theory Paper-III Ordinary Differential Equations | 45 | 70 | 30 | 100 | 02 |
| | ASPUSMTP02 | Practical based on Paper I, II and III | 05 | 35 | 15 | 50 | 03 |

| Semester III Theory Paper I | | | |
|---|---|---|---|
| Learning Objectives:<br>The students will be able to understand-<br>Outline the concepts of Euclidean Space.<br>Analyze the properties of Scalar field and Vector field.<br>Directional derivatives of scalar field.<br>Analyze mean value theorem. | | | |
| Course Code<br>ASPUSMT301 | Title | Lectures | Credits |
| Unit | Calculus III | 45 | 02 |
| Unit I<br>Functions of several variables | 1.The Euclidean inner product on $\mathbb{R}^n$ and Euclidean norm function on $\mathbb{R}^n$, distance between two points, open ball in $\mathbb{R}^n$, definition of an open subset of $\mathbb{R}^n$, neighbourhood of a point in $\mathbb{R}^n$, sequences in $\mathbb{R}^n$, convergence of sequences- these concepts should be specifically discussed for $\mathbb{R}^2$ and $\mathbb{R}^3$<br>2. Functions from $\mathbb{R}^n$ to $\mathbb{R}$ (scalar fields) and functions from $\mathbb{R}^n \rightarrow \mathbb{R}^m$ (vector fields), limits and continuity of functions, basic results on limits and continuity of sum, difference, scalar multiples of vector fields, continuity and components of a vector field.<br>3. Directional derivatives and partial derivatives of scalar fields.<br>4. Mean value theorem for derivatives of scalar fields. | 15 | |
| Unit II<br>Differentiation | 1. Differentiability of a scalar field at a point of $\mathbb{R}^n$ (in terms of linear transformation) and on an open subset of $\mathbb{R}^n$, the total derivative, uniqueness of total derivative of a differentiable function at a point, simple examples of finding total derivative of functions such as $f(x, y) = x^2 + y^2$, $f(x, y, z) = x + y + z$,<br>2. Differentiability at a point of a function f implies continuity and existence of direction derivatives of f at the point, the existence of continuous partial derivatives in a neighbourhood of a point implies differentiability at the point.<br>3. Gradient of a scalar field, geometric properties of gradient, level sets and tangent planes. Chain rule for scalar fields.<br>4. Higher order partial derivatives, mixed partial derivatives, sufficient condition for equality of mixed partial derivatives. | 15 | |
| Unit III<br>Applications | 1. Second order Taylors formula for scalar fields. Differentiability of vector fields, definition of differentiability of a vector field at a point, Jacobian matrix, and differentiability of a vector field at a point implies continuity.<br>2. The chain rule for derivative of vector fields (statements only) Mean value inequality. Hessian matrix, Maxima, minima and saddle points.<br>3. Second derivative test for extrema of functions of two variables.<br>4. Method of Lagrange multipliers. | 15 | |

| Semester III Theory Paper II | | | |
|---|---|---|---|
| Learning Objectives:<br>The students will be able to understand-<br>Learner will be able to experiment with linear transformations.<br>Learner will be able to explain concept of Matrices and Determinant.<br>Learner will be able to explain the properties of Inner product Spaces. | | | |
| Course Code ASPUSMT302 | Title | Lectures | Credits |
| Unit | Linear transformations and Matrices | 45 | 02 |
| Unit I<br>Linear transformations and Matrices | 1. Rank-Nullity theorem and applications. Composite $S \circ T$ of linear maps $T : V \to W$ & $S : W \to U$ of. real vector spaces V,W,U and matrix representation of $S \circ T$. Linear isomorphisms, inverse of a linear isomorphism. Any n-dimensional real vector space is isomorphic to $\mathbb{R}^n$.<br><br>2. Linear transformations, representation of linear maps by matrices and effect under a change of basis, examples. Kernel and image of a linear transformation, examples.<br><br>3. The following are equivalent for a linear map $T : V \to V$ of a finite dimensional real vector space :<br>1. T is an isomorphism.<br>2. $\ker T = \{0\}$.<br>3. $\mathrm{Im}(T) = V$.<br>4. The matrix units, row operations, elementary matrices. Elementary matrices are invertible and an invertible matrix is a product of elementary matrices.<br>Row space and column space of a matrix, row rank and column rank of a matrix, equivalence of the row and the column rank, invariance of rank upon elementary row or column operation $\mathbb{R}^n$ is the space of column vectors $x = \begin{pmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ x_n \end{pmatrix}$ where each $x_j \in \mathbb{R}$, equivalence of rank of an $n \times n$-matrix and rank of the linear transformation $L_A : \mathbb{R}^n \to \mathbb{R}^m (L_A(x) = Ax \ \forall\ x \in \mathbb{R}^n)$,the dimension of solution space of the system of linear equations $Ax = 0$ equals $n - \mathrm{rank}(A)$.<br>The solutions of non-homogeneous systems of linear equations represented by $Ax = b$; existence of a solution when $\mathrm{rank}(A) = \mathrm{rank}(A, b)$; the general solutions of the system is the sum of a particular solution of the system and the solutions of the associated homogeneous system. | 15 | |
| Unit II<br>Matrices and Determinants | 1. Determinant $D(A^1, A^2)$ of order 2 and its properties:<br>1. As a function of column vectors, the determinant is linear.<br>2. If the two columns are equal, then the determinant is equal to 0.<br>3. If I is the unit matrix, $I = (E^1, E^2)$, then $D(E^1, E^2) = 1$.<br><br>Results on Determinants of order 2 :<br>1. If one adds a scalar multiple of one column to the other, then the value of the determinant does not change.<br>2. The determinant of A is equal to the determinant of its | 15 | |

| | | | |
|---|---|---|---|
| | transpose.<br>3. Two vectors $A^1$, $A^2$ of $\mathbb{R}^2$ are linearly dependent if and only if the determinant $D(A^1, A^2) = 0$.<br>4. Let φ be a function of two variables $A^1, A^2 \in \mathbb{R}^2$ such that φ is bilinear (i.e. φ is linear in each variable), $\varphi(A^1, A^1) = 0 \ \forall A^1$ $\mathbb{R}^2$ and $\varphi(E^1, E^2) = 1$ where $E^1 = \begin{pmatrix}1\\0\end{pmatrix}$, $E^2 = \begin{pmatrix}0\\1\end{pmatrix}$ are the standard unit vectors of $\mathbb{R}^2$, then $\varphi(A^1, A^2)$ is the determinant $D(A^1, A^2)$.<br><br>2. Determinants of order 3×3, n×n, expansion of the determinant according to i-th row, properties of the determinant function. Results (without proof): For two n × n matrices A&B, $Det(A) = Det({}^tA)$, $Det(AB) = Det(A)Det(B)$.<br>Linear dependence and independence of vectors in $\mathbb{R}^n$ using determinants, the existence and uniqueness of the system Ax = b where A is an n × n-matrix with $det(A) \neq 0$.<br>Cofactors and minors, adjoint adj(A) of an n × n-matrix A, A adj(A) = det(A)Id (without proof). A n × n- real matrix is invertible if and only if $det(A) \neq 0$ and $A^{-1} = \frac{1}{\det(A)}$ adj(A) for an invertible matrix A.<br>3. Cramer's rule. Determinant as area and volume. | | |
| Unit III<br>Inner Product Spaces. | 1. Dot product in $R^n$; Definition of general inner product on a vector space over R: Examples of inner product including the inner product $< f; g >= \int_a^b f(t)g(t)dt$ on $C[a, b]$ the space of continuous real valued functions on $[a, b]$.<br>Norm of a vector in an inner product space. Cauchy-Schwartz inequality, Triangle in-equality, Orthogonality of vectors, Pythagoras theorem and geometric applications in $R^2$; Projections on a line, the projection being the closest approximation, Orthogonal complements of a subspace, Orthogonal complements in $R^2$ and $R^3$. Orthogonal sets and Orthonormal sets in an inner product space, Orthogonal and orthonormal bases. Gram-Schmidt orthogonalization process, Simple examples in $R^3$; $R^4$. | 15 | |

| Semester III Theory Paper III | | | |
|---|---|---|---|
| Learning Objectives:<br>The students will be able to understand-<br>Learner will be able to experiment with countable and uncountable sets also Stirling numbers.<br>Learner will be able to explain some concept of Combinatorics.<br>Learner will be able to explain the properties of permutation and recurrence relation . | | | |
| Course Code ASPUSMT303 | Title | Lectures | Credits |
| Unit | Discrete Mathematics | 45 | 02 |
| Unit I Preliminary Counting | 1. Finite and infinite sets, Countable and uncountable sets, examples such as $N, Z, N \times N, Q, (0, 1), R$.<br><br>2. Addition and multiplication principle, Counting sets of pairs, two way counting.<br><br>3. Stirling numbers of second kind, Simple recursion formulae satisfied by $S(n\, , k)$and direct formulae for $S(n\, , k)$ for $k = 1,2, \dots \dots . . n-1, n.$<br><br>4. Pigeon hole principle and its strong form, its applications to geometry, monotonic<br>sequences, etc | 15 | |
| Unit II Advanced Counting | 1. Binomial and Multinomial Theorem, Pascal identity, examples of standard identities such as the following with emphasis on combinatorial proofs.<br>$$\sum_{k=0}^{r} \binom{m}{k}\binom{n}{r-k} = \binom{m+n}{r}$$ $$\sum_{i=r}^{n} \binom{i}{r} = \binom{n+1}{r+1}$$ $$\sum_{i=0}^{k} \binom{k}{i}^2 = \binom{2k}{k}$$ $$\sum_{i=0}^{n} \binom{n}{i} = 2^n$$<br>2. Permutation and combination of sets and multi-sets, circular permutations, emphasis on solving problems.<br><br>3. Non-negative and positive integral solutions of equation $x_1 + x_2 + \dots . . + x_k = n$<br><br>4. Principle of Inclusion and Exclusion its applications, derangements, explicit formula for $dn$ various identities involving $d_n$ deriving formula for Euler's phi function $\varphi(n)$. | 15 | |
| Unit III Permutations and Recurrence relation. | 1. Permutation of objects, $S_n$,composition of of permutations, results such as every permutation is product of disjoint cycles, every cycle is product of transpositions, even and odd permutations, rank and signature of permutation, cardinality of $S_n, A_n$ .<br>2. Recurrence relation, definition of homogeneous, non-homogeneous, linear and non-linear recurrence relation, obtaining recurrence relation in counting problems, solving ( homogeneous as well as non-homogenous) recurrence relation by using iterative method, solving a homogeneous recurrence relation of second degree using algebraic method proving the necessary result | 15 | |

| Course Code ASPUSMTP01 Semester III Practical Paper I – Calculus III | | | |
|---|---|---|---|
| Sr.No. | Practicals | L | Cr |
| | | 15 | 01 |
| Use open and free source software Scilab for Computing | | | |
| 1. | Sequences in $R^2$, $R^3$, limits and continuity of scalar fields and vector fields using ’definition ‘and otherwise, iterated limits. | | |
| 2. | Computing directional derivatives, partial derivatives and mean value theorem of scalar fields. | | |
| 3. | Total derivative, gradient, level sets and tangent planes. | | |
| 4. | Chain rule, higher order derivatives and mixed partial derivatives of scalar fields. | | |
| 5. | Taylor’s formula, differentiation of a vector field at a point, finding Hessian/Jacobean<br>matrix, Mean value inequality. | | |
| 6. | Finding maxima, minima and saddle points, second derivative test for extrema of functions of two variables and method of Lagrange multipliers. | | |

| Course Code ASPUSMTP01 Semester III Practical Paper II – Linear transformations and Matrices | | | |
|---|---|---|---|
| Sr.No. | Practicals | L | Cr |
| | | 15 | 01 |
| | Use open and free source software Scilab for Computing | | |
| 1. | Rank-Nullity Theorem. | | |
| 2. | System of linear equations. | | |
| 3. | Computation of row rank and column rank of $3 \times 3$ matrices. | | |
| 4. | Calculating determinants of matrices, triangular matrices using definition and Laplace expansion. | | |
| 5. | Finding inverses of matrices using adjoint.<br>1. Groups, Subgroups, LaGrange’s Theorem, Cyclic groups and Groups of Symmetry.<br>2. Group homomorphisms, isomorphisms. | | |

| Course Code ASPUSMTP01 Semester III Practical Paper III – Discrete Mathematics | | | |
|---|---|---|---|
| Sr.No. | Practicals | L | Cr |
| | | 45 | 01 |
| | Use open and free source software Scilab for Computing | | |
| 1. | Problems based on counting principles, Two way counting. | | |
| 2. | Stirling numbers of first and second kind, Pigeon hole principle | | |
| 3. | Multinomial theorem, identities, permutation and combination of multi-set. | | |
| 4. | Inclusion-Exclusion principle, Euler phi function. | | |
| 5. | Derangement and rank signature of permutation | | |
| 6. | Recurrence relation | | |

| Semester IV Theory Paper I | | | |
|---|---|---|---|
| Learning Objectives:<br>The students will be able to understand-<br>Learner will be able to explain the properties of Riemann Integration.<br>Learner will be able to explain the Indefinite and improper integrals.<br>Learner will be able to test the application of integration. | | | |
| Course Code ASPUSMT401 | Title | Lectures | Credits |
| Unit | Calculus IV | 45 | 02 |

| | | | |
|---|---|---|---|
| Unit I<br>Riemann<br>Integration | 1. Approximation of area, Upper / Lower Riemann sums and properties, Upper / Lower integrals, Definition of Riemann integral on a closed and bounded interval, Criterion for Riemann integrability, a < c < b then $f \in R[a,b]$ iff $f \in R[a,c]$ $f \in R[c,b]$ and $\int_a^b f = \int_a^c f + \int_c^b f$.<br><br>2 Properties: If $f, g \in R[a,b] \rightarrow f+g, af \in R[a,b]$ and $\int_a^b f+g = \int_a^c f + \int_c^b g$, $\int_a^b af = a\int_a^c f$, $f \in R[a,b] \rightarrow \lvert f \rvert \in R[a,b]$ and $\left\lvert \int_a^b f \right\rvert \leq \int_a^b \lvert f \rvert$, $f \geq 0 \Longrightarrow \int_a^b f \geq 0$, $f \in C[a,b] \rightarrow f \in R[a,b]$. If f is bounded with finite number of discontinuities then $f \in R[a,b]$ generalize this if $f$ is monotone then $f \in R[a,b]$. | 15 | |
| Unit II<br>Indefinite and improper integrals | 1. Continuity of $F(x) = \int_a^x f(t)dt$ where $f \in R[a,b]$. Fundamental theorem of calculus, Mean value theorem, Integration by parts, Leibnitz rule,<br><br>2. Improper integrals- type 1 and type 2, Absolute convergence of improper integrals, Comparison tests, Abel's and Dirichlet's tests (without proof) □□and □□functions and their properties, relationship between □□and □□functions. | 15 | |
| Unit III<br>Applications | 1. Topics from analytic geometry- sketching of regions in $\mathbb{R}^2$ and $\mathbb{R}^3$, graph of a function, level sets, Cartesian coordinates, polar coordinates, spherical coordinates, cylindrical coordinates and conversions from one coordinate system to another.<br><br>2. Double integrals: Definition of double integrals over rectangles, properties, double integrals over a bounded region.<br><br>3. Fubini theorem (without proof)- iterated integrals, double integrals as volume.<br><br>4. Application of double integrals: average value, area, moment, center of mass.<br><br>5. Double integral in polar form. | 15 | |

| Semester IV Theory Paper II | | | |
|---|---|---|---|
| Learning Objectives:<br>The students will be able to understand-<br>Learner will be able to experiment with concept and properties of Groups and Subgroups.<br>Learner will be able to explain properties of Cyclic Groups and Cyclic Subgroups.<br>Learner will be able to know properties of cosets.<br>Learner will be able to explain the concept of homomorphisms and isomorphisms, automorphisms. | | | |
| Course Code<br>ASPUSMT402 | Title | Lectures | Credits |
| Unit | Algebra III | 45 | 02 |
| Unit I<br>Groups and<br>Subgroups | (a) Definition of a group, abelian group, order of a group, finite and infinite groups. Examples of groups including<br>(i) $\mathbb{Z}, \mathbb{Q}, \mathbb{R}, \mathbb{C}$ under addition.<br>(ii) $\mathbb{Q}^* = (= \mathbb{Q}\backslash\{0\})$, $\mathbb{R}^* = (= \mathbb{R}\backslash\{0\})$, $\mathbb{C}^* = (= \mathbb{C}\backslash\{0\})$, $\mathbb{Q}^+$(= positive rational numbers) under multiplication. | 15 | |

| | | | |
|---|---|---|---|
| | (iii) $\mathbb{Z}_n$ the set of residue classes modulo $n$ under addition.<br>(iv) $U(n)$ the group of prime residue classes modulo $n$ under multiplication.<br>(v) The symmetric group $S_n$<br>(vi) The group of symmetries of a plane figure. The Dihedral group $D_n$ as the group of symmetries of a regular polygon of $n$ sides (for $n = 3, 4$).<br>(vii) Klein 4-group.<br>(viii) Matrix groups $M_{m\times n}(\mathbb{R})$ under addition of matrices, $GL_n(\mathbb{R})$ the set of invertible real matrices, under multiplication of matrices.<br>(ix) Examples such as S', $\mu_n$ the $n^{th}$ roots of unity as subgroups of $\mathbb{C}$ *.<br><br>Properties such as :<br>1) In a group (G,.) the following indices rules are true for all integers n, m<br>i) $a^n a^m = a^{m+n}$ for all a in G.<br>ii) $(a^n)^m = a^{nm}$ for all a in G.<br>iii) $(ab)^n = a^n b^n$ for all a, b in G, whenever ab = ba.<br><br>2) In a group (G, .) the following are true<br>i) The identity element e of G is unique.<br>ii) The inverse of every element in G is unique.<br>iii) $(a^{-1})^{-1} = a$<br>iv) $(a.b)^{-1} = b^{-1}a^{-1}$<br>v) If $a^2 = e$ for every a in G then (G, .) is an abelian group.<br>vi) $(aba^{-1})^n = ab^n a^{-1}$ for every a,b in $G$ and for every integer $n$.<br>vii) If $(a.b)^2 = a^2.b^2$ for every a,b in $G$ then (G, .) is an abelian group<br>viii) $(\mathbb{Z}_n^*, .)$ is a group if and only if $n$ is a prime.<br><br>3) Properties of order of an element such as (n and m are integers)<br>i) If $o(a) = n$ then $a^m = e$ if and only if $n \mid m$<br>ii) If $o(a) = nm$ then $o(a^n) = m$<br>iii) If $o(a) = n$ then $o(a^n)) = \frac{n}{(n,m)}$<br>where $(n, m)$ is the GCD of $n$ and $m$.<br>iv) $o(aba^{-1}) = o(b)$ and $o(ab) = o(ba)$.<br>v) If $o(a) = n$ and $o(b) = m, ab = ba, (n, m) = 1$ then $o(ab) = nm$<br><br>(b) Subgroups :<br>1) Definition, necessary and sufficient condition for a non-empty set to be a Subgroup.<br>2) The center $Z(G)$ of a group is a subgroup.<br>3) Intersection of two (or a family of) subgroups is a subgroup<br>4) Union of two subgroups is not a subgroup in general. Union of two subgroups is a subgroup if and only if one is contained in the other.<br>5) If $H$ and $K$ are subgroups of a group G then $HK$ is a subgroup of $G$ if and only if $HK = KH$ | | |
| Unit II<br>Cyclic groups and | (a) Cyclic subgroup of a group, cyclic groups, (examples including $Z, z_n$ *and* $\mu_n$). | 15 | |

| | | | |
|---|---|---|---|
| cyclic subgroups | (b) Properties such as<br>(i) Every cyclic group is abelian<br>(ii) Finite cyclic groups, infinite cyclic groups and their generators.<br>(iii) A finite cyclic group has a unique subgroup for each divisor of the order of<br>the group<br>(iv) Subgroup of a cyclic group is cyclic<br>(v) In a finite group $G$ , $G = < a >$, if and only if $o(G) = o(a)$<br>(vi) If $G = < a > and\ o(a) = n$ and then $G =< a^m >$ if and only if $(m,n) = 1$.<br>(vii) If $G$ is a cyclic group of order $p^n$and $H < G, K < G$ then prove that either $H \subseteq K\ or\ K \subseteq H$. | | |
| Unit III<br>Lagrange's Theorem and Group homomorphism | a) Definition of Coset and properties such as<br><br>1) If H is a subgroup of a group G and $x \epsilon G$ then prove that<br>i) $xH = H$ if and only if $x \epsilon H$<br>ii) $Hx = H$ if and only if $x \epsilon H$<br><br>2) If $H$ is a subgroup of a group G and $x, y \epsilon G$ then prove that<br>i) $xH = yH$ if and only if $x^{-1}y \epsilon H$<br>ii) $Hz = H$y if and only if $xy^{-1} \epsilon H$<br><br>3) Lagrange's theorem and consequences such as Fermat's Little theorem, Eulers's theorem and If a group $G$ has no nontrivial subgroups then order of $G$ is a prime and $G$ is Cyclic etc<br><br>(b) Group homomorphisms and isomorphisms, automorphisms<br>(i) Definition.<br>(ii) Kernel and image of a group homomorphism.<br>(iii) Examples including inner automorphism.<br>Properties such as<br>1) $f: G \to G'$ is a group homomorphism then ker $f < G$<br>$f: G \to G'$ is a group homomorphism then<br>ker $f = \{e\}$ if and onlf if $f$ is 1-1<br>$f: G \to G'$ is an isomorphism of groups then<br>i) $G$ is abelian if and only if $G'$ is abelian<br>ii) $G$ is cyclic if and only if $G'$is cyclic. | 15 | |

| | | | |
|---|---|---|---|
| Semester IV Theory Paper III | | | |
| Learning Objectives:<br>The students will be able to understand-<br>Learner will be able to experiment with the First order differential equation.<br>Learner will be able to identify types of non- homogeneous differential equations.<br>Learner will be able to explain properties Second order differential equation..<br>Learner will be able to solve examples on first and second order differential equation..<br>Learner will be able to explain properties and examples on system of first order linear differential Equation.. | | | |
| Course Code<br>ASPUSMT403 | Title | Lectures | Credits |
| Unit | Ordinary Differential Equation | 45 | 02 |
| Unit I<br>First order | 1.Definition of a differential equation, order, degree, ordinary differential equation and partial differential equation, linear and | 15 | |

| | | | |
|---|---|---|---|
| equations | non-linear ODE,<br><br>2. Existence and Uniqueness Theorem for the solutions of a second order initial value problem (statement only). Define Lipschitz function; solve examples verifying the conditions of existence and uniqueness theorem,<br><br>3. Review of solution of homogeneous and non- homogeneous differential equations of first order and first degree. Notion of partial derivative. Exact Equations: General Solution of Exact equations of first order and first degree. Necessary and sufficient condition for $Mdx + n\,y = 0$ to be exact. Non-exact equations. Rules for finding integrating factors (without proof) for non-exact equations, such as<br>i) $1/Mx\ + Ny$<br>is an I.F. If $Mx\ + Ny\ \neq 0$ and $Mdx + Ndy$ is homogeneous<br>ii) $\frac{1}{Mx-Ny}$ is an I.F. if $Mx - Ny \neq 0$ and $Mdx - Ndy$ is of the type $f_1(xy)ydx + f_2(x,y)x\,dy$ iii) $e^{\int f(x)dx}$ (resp $e^{\int g(y)dy}$) is an I.F. if N $\neq 0$ (resp M$\neq 0$ ) and $\frac{1}{N}\left(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right)$ ( resp $\frac{1}{M}\left(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right)$ ) is a function of x ( resp y)alone, say $f(x)\ (resp\ g(y))$.<br><br>4. Linear and reducible to linear equations, finding solutions of first order differential equations of the type for applications to orthogonal trajectories, population growth, and finding the current at a given time. | | |
| Unit II<br>Second order equations | 1.Homogeneous and non-homogeneous second order linear differentiable equations: The space of solutions of the homogeneous equation as a vector space. Wronskian and linear independence of the solutions. The general solution of homogeneous differential equation. The use of known solutions to find the general solution of homogeneous equations. The general solution of a non-homogeneous second order equation. Complementary functions and particular integrals,<br><br>2. The homogeneous equation which constant coefficient. auxiliary equation. The general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation,<br><br>3. Non-homogeneous equations: The method of undetermined coefficients. The method of variation of parameters. | 15 | |
| Unit III | System of linear homogeneous differential equation. The general and particular solution of system of homogeneous differential equation. Wronskian of system of differential equation. Non-homogeneous equations: The method of undetermined coefficients. The method of variation of parameters. | 15 | |

| Course Code ASPUSMTP02 Semester IV Practical Paper I – Calculus IV | | | |
|---|---|---|---|
| Sr.No. | Practicals | L<br>30 | Cr<br>01 |

| | | | |
|---|---|---|---|
| | Use open and free source software Scilab for Computing | | |
| 1. | Calculation of upper sum, lower sum and Riemann integral.<br>by parts, Leibnitz rule.<br>Sketching of regions in *IR2* and *IR3*, graph of a function, level sets, and conversions from one coordinate system to another. | | |
| 2. | Problems on properties of Riemann integral. | | |
| 3. | Problems on fundamental theorem of calculus mean value theorems, integration | | |
| 4. | Convergence of improper integrals, applications of comparison tests, Abel's and Dirichlet's test, and functions. | | |
| 5. | Sketching of regions in *IR2* and *IR3*, graph of a function, level sets, and conversions from one coordinate system to another. | | |
| 6. | Double integrals, iterated integrals, applications to compute average value, area, moment, center of mass. | | |

| Course Code ASPUSMTP02 Semester IV Practical Paper II – Algebra III | | | |
|---|---|---|---|
| Sr.No. | Practicals | L<br>30 | Cr<br>01 |
| | Use open and free source software Scilab for Computing | | |
| 1. | Examples and properties of groups | | |
| 2. | Group of symmetry of equilateral triangle, rectangle, square | | |
| 3. | Subgroups | | |
| 4. | Cyclic groups, cyclic subgroups, finding generators of every subgroup of a cyclic group | | |
| 5. | Left and right cosets of a subgroup, Lagrange's Theorem. | | |
| 6. | Group homomorphisms, isomorphisms | | |

| Course Code ASPUSMTP02 Semester IV Practical Paper III – Ordinary Differential Equation | | | |
|---|---|---|---|
| Sr.No. | Practicals | L<br>30 | Cr<br>01 |
| | Use open and free source software Scilab for Computing | | |
| 1. | Application of existence and uniqueness theorem, solving exact and non-exact equations. | | |
| 2. | Linear and reducible to linear equations, applications to orthogonal trajectories, population growth, and finding the current at a given time. | | |
| 3. | Finding general solution of homogeneous and non-homogeneous equations, use of known solutions to find the general solution of homogeneous equations. | | |
| 4. | Solving equations using method of undetermined coefficients and method of variation of parameters | | |
| 5. | Solving system of equations using method of undetermined coefficients and method of variation of parameters | | |
| 6. | Examples on Lagrange’s Multiplier method. | | |

Reference Books

1. K. Hoffman and R. Kunze: Linear Algebra, Tata McGraw-Hill, New Delhi.
2. M. Artin: Algebra, Prentice Hall of India Private Limited.
3. Gareth Williams: Linear Algebra with Applications, Narosa Publication.
4. V. Krishnamurthy: Combinatorics – Theory and Applications, Affiliated East West Press.
5. Discrete Mathematics and its Applications, Tata McGraw Hills.
6. Schaum’s outline series : Discrete mathematics,
7. Applied Combinatorics: Allen Tucker, John Wiley and Sons
8. T. Apostol, Calculus, Vol. 2, John Wiley.
9. J. Stewart, Calculus, Brooke/Cole Publishing Co.
10. Calculus, Vol. 2, T. Apostol, John Wiley.

11. Calculus. J. Stewart. Brooke/Cole Publishing Co.
12. I.N. Herstein, Algebra.
13. P.B. Bhattacharya, S.K. Jain, S. Nagpaul. Abstract Algebra.
14. M. Artin, Algebra, Prentice Hall of India, New Delhi.
15. J.B. Fraleigh, A first course in Abstract Algebra, Third edition, Narosa, New Delhi.
16. I.N. Herstein. Topics in Algebra, Wiley Eastern Limited, Second edition.
17. Differential equations with applications and historical notes, G. F. Simmons, McGraw Hill.
18. An introduction to ordinary differential equations, E. A. Coddington
19. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964
20. Ajit Kumar, S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
21. T. Apostol, Calculus Vol.2, , John Wiley
22. J. Stewart, Calculus, Brooke/Cole Publishing Co, 1994.
23. J. E. Marsden, A. J. Tromba and A. Weinstein, Basic multivariable calculus.
24. Bartle and Sherbet, Real analysis

Evaluation Pattern
External evaluation: Internal evaluation (70:30)
Theory:-External evaluation (70 Marks) Question Paper Pattern
Time: 2.5 hours

| No. | Question Pattern | Marks |
|---|---|---|
| Q.1 | Fill in the blanks by choosing appropriate options (10 MCQs) | 10 |
| Q.2 | a) Long Answer Questions (based on Unit I) | 15 |
| | b) Short Answer Questions (based on Unit I) | |
| Q.3 | a) Long Answer Questions (based on Unit II) | 15 |
| | b) Short Answer Questions (based on Unit II) | |
| Q.4 | a) Long Answer Questions (based on Unit III) | 15 |
| | b) Short Answer Questions (based on Unit III) | |
| Q.5 | b) Long Answer Question (based on Unit I, II & III) | 15 |
| Total | | 70 |

Theory:-Internal evaluation (30 Marks)

| Description | Marks |
|---|---|
| Test | 10 |
| Assignment | 10 |
| Overall Conductance | 10 |
| Total | 30 |

Paper pattern for each course : ASPUSMT301, ASPUSMT302 and ASPUSMT303
ASPUSMT401, ASPUSMT402 and ASPUSMT403

Practical:-Internal evaluation (50 Marks) Question Paper Pattern

| No. | Question Pattern | Marks |
|---|---|---|
| Q.1 | Short answer question | 20 |
| Q.2 | Long Answer Questions | 15 |
| | Performance in Regular Practical’s | 05 |
| | Viva | 05 |
| | Journal | 05 |
| Total | | 50 |

Expected Learning Outcomes
(Programme Outcomes, Programme Specific Outcomes, Course Outcomes )

B.Sc. Mathematics
Programme Outcomes
PO1. Acquires the ability to understand and analyze the problems.
PO2. Develops the skill to think critically on abstract concept of mathematics
PO3. Acquire the ability to think independently paving way for lifelong learning.
PO4.Analyses the situation, make a mathematical problem and find its solution.
PO5. Enhance logical reasoning skills, arithmetic skills, aptitude skills, communication skills, self-confidence for better employability.
PO6. Formulates and develops mathematical arguments in logical manner.
PO7. Provide a systematic understanding of the concepts and theories of mathematical and computing their applications in the real world.

Programme Specific Outcomes: (PSO)s of B.Sc. Mathematics:
PSO 1. Critically evaluation of ideas and arguments by collection relevant information about the units for study.
PSO 2. Identify problems and independently propose solutions using creative approaches, acquired through interdisciplinary experiences, and a depth and breadth of knowledge/expertise in the field.
PSO 3. Students will be able to apply fundamental mathematical tools (statistics, calculus) and physical principles (physics, chemistry) to the analysis of relevant biological situations.
PSO4. Student will able to solve mathematical argument and proofs to solve problems and to promote understanding, to apply mathematical knowledge to a career related to mathematical science.
Course Outcomes of B.Sc. Mathematics
After completion of course following learning outcomes are expected.
Students will learn and understand the syllabus.

Annexure II: Panel of examiners

| Sr.No. | Name of the faculty | Name of the paper |
|---|---|---|
| 1. | Dr. Rajeev Sapre,<br>Associate Professor,<br>Gogate Joglekar College,<br>Ratnagiri. | Paper-III(Discrete Maths) and Maths-III(ODE ) |
| 2. | Mr. Ranjan Khatu<br>Assistant Professor,<br>ACS College, Lanja,<br>Dist. – Ratnagiri. | Maths-I (Calculus-IV) and Maths-I (Calculus-III) |
| 3. | Mr. Ganesh Kadu<br>Assistant Professor,<br>ACS College, Lanja,<br>Dist. – Ratnagiri. | Maths-II(Algebra-IV) |
| 4. | Mr. Vishwas Sonalkar<br>Assistant Professor,<br>SPK, College, Sawantwadi,<br>Dist. – Sindhudurg. | Maths-I (Calculus-IV) and Maths-II(Algebra-III) |
| 5. | Dr. Ashok Bingi<br>Assistant Professor,<br>St. Xaviers'College-Autonomous, Mumbai,<br>Mumbai. | Maths-II(Algebra-IV) |
| 6. | Mr. S.S. Salgare<br>Assistant Professor,<br>SGU, Kolhapur. | Maths-III (ODE) |
| 7. | Mr. Rahul B Deshmukh<br>Assistant Professor,<br>SRM College, Kudal,<br>Dist. – Sindhudurg. | Maths-II(Algebra-III) |
| 8. | Mr. Subhash Unhale<br>Assistant Professor,<br>CKT College, Panvel,<br>Dist. – Raigad. | Maths-I (Calculus-III) |
| 9. | Mr..Nitinkumar Potadar,<br>Assistant Professor,<br>Ramnarain Ruia College,<br>LN Road ,Matunga East,<br>Mumbai-19. | Maths-III(Discrete Mathematics) |