

**HIMACHAL PRADESH UNIVERSITY****B.A./B.Sc.(Mathematics)**

**List of Major Core, Elective, Open Elective, Skill Based, GI & H Courses for UG(B.A./B.Sc.) Degree offered by the Mathematics Department under CBCS Semester system scheme effective from Academic Year 2013 onwards**

**a). List of Major Core Courses**

Sem	Course Code	Course Type	Title of Paper	Credits
<b>I</b>	BA/BSCMATH0101	Major Core Course-I	Algebra and Trigonometry	4
<b>I</b>	BA/BSCMATH0102	Major Core Course-II	Calculus	4
<b>II</b>	BA/BSCMATH0203	Major Core Course-III	Ordinary Differential Equations	4
<b>II</b>	BA/BSCMATH0204	Major Core Course-IV	Solid Geometry	4
<b>III</b>	BA/BSCMATH0305	Major Core Course-V	Sequences and Series	4
<b>III</b>	BA/BSCMATH0306	Major Core Course-VI	Statics & Dynamics	4
<b>IV</b>	BA/BSCMATH0407	Major Core Course-VII	Vector Calculus	4
<b>IV</b>	BA/BSCMATH0408	Major Core Course-VIII	Real Analysis	4
<b>IV</b>	BA/BSCMATH0409	Major Core Course-IX	Abstract Algebra	4
<b>V</b>	BA/BSCMATH0510	Major Core Course-X	Partial Differential Equations	4
<b>V</b>	BA/BSCMATH0511	Major Core Course-XI	Linear Algebra	4
<b>V</b>	BA/BSCMATH0512	Major Core Course-XII	Complex Analysis	4
<b>VI</b>	BA/BSCMATH0613	Major Core Course-XIII	Advanced Calculus	4
<b>VI</b>	BA/BSCMATH0614	Major Core Course-XIV	Numerical Analysis	3
<b>VI</b>	BA/BSCMATH0614 (P)	Major Core Lab Course -XIV	Numerical Analysis- <b>Lab 1</b>	1

**b). List of Minor Elective Courses**

Sem	Course Code	Course Type	Title of Paper	Credits
<b>I</b>	BA/BSCMATH0102	<b>Minor Elective-I</b>	Calculus	4
<b>II</b>	BA/BSCMATH0203	<b>Minor Elective-II</b>	Ordinary Differential Equations	4
<b>III</b>	BA/BSCMATH0305	<b>Minor Elective-III</b>	Sequences and Series	4
<b>IV</b>	BA/BSCMATH0407	<b>Minor Elective-IV</b>	Vector Calculus	4
<b>V</b>	BA/BSCMATH0510	<b>Minor Elective-V</b>	Partial Differential Equations	4

**c) List of Core Elective Courses (Additional)**

Sem	Course Code	Course Type	Title of Paper	Credits
<b>IV</b>	BA/BSCMATH0415	Core Elective Course (Additional)	Hydrostatics	4
<b>V</b>	BA/BSCMATH0516	Core Elective Course (Additional)	Mechanics	4

**d). List of Open/Core Elective Courses**

Sem.	Course Code	Course Type	Title of Paper	Credits
VI	BA/BSCMATH0617	Open/Core Elective Course(Additional)	Elementary Number Theory	4
VI	BA/BSCMATH0618	Open/ Core Elective Course (Additional)	Discrete Mathematics	4
VI	BA/BSCMATH0619	Open /Core Elective Course (Additional)	Statistics	4
VI	BA/BSCMATH0620	Open /Core Elective Course (Additional)	Mathematical Modelling	4
VI	BA/BSCMATH0621	Open / Core Elective Course (Additional)	Linear Programming	4
VI	BA/BSCMATH0622	Open / Core Elective Course (Additional)	Financial Mathematics	4

**e) Compulsory Course ( Skill Based) offered by Mathematics Department:**

Semester	Course Code	Course Type	Title of Paper	Credits
I/II/III	BA/BSCMATH01/02/0323	Compulsory Course(Skill Based)	Basic Mathematics For All	3

**e) GI & H Courses offered by Mathematics Department**

Sem.	Course Code	Course Type	Title of Course	Credits
I/II/III	BA/BSCMATH01/02/03 24	GI and H	Basic Numeracy, Logical Reasoning and Data Interpretation	2

List of Some of the popular Web resources which offer **free e-learning** material (downloadable) either in lecture/assignments/tutorial/solution format or even video lecture format accessible on YouTube also:

- i) National Programme on Technology Enhanced Learning (NPTEL) initiative of Govt. of India through Seven IITS and IIMs available through the websites: [www.nptel.iitm.ac.in](http://www.nptel.iitm.ac.in), [www.iitk.ac.in](http://www.iitk.ac.in) etc.
- ii) Indira Gandhi National Open University (IGNOU) hosts a large repository of quality study material, at its web-site, which is freely downloadable after doing simple registration.
- iii) **Khan Academy** is an internationally popular web resource on almost all conceivable topics of interest which provides free video lectures in the topic-wise format, covering almost all of mathematics of college level. Web-site can be accessed at the internet address [www.khanacademy.org](http://www.khanacademy.org).
- iv) Internationally reputed Massachusetts Institute of Technology (MIT) USA also provides Open Courseware in lecture/video format for free at its website.
- v) Stanford University USA is also a good source of some learning materials under the scheme 'Stanford Engineering Everywhere' on the web address [www.see.stanford.edu](http://www.see.stanford.edu) .
- vi) Our IITS and some Universities also provide ready access to some study material.

**HIMACHAL PRADESH UNIVERSITY**  
**B.A./B.Sc.(Mathematics) Examination**

**First Semester**

Course Code	BA/BSCMATH0101
Credits= 4	L-4,T-0,P-0
Name of the Course	Algebra and Trigonometry
Type of the Course	(Major Core Course I)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50 Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

- Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.
- Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I (12 hrs.)**

Definition of Matrices, symmetric and skew-symmetric matrices, Hermitian and skew-Hermitian matrices. Elementary operations on matrices and their use to find the linear dependence and independence of row and column vectors.( 6 hrs.)

Dimensions of row and column spaces, row-rank, column-rank and rank of a matrix (Normal form) (6 hrs.)

**Unit II(16 hrs.)**

Eigenvalues, eigen vectors and the characteristic equation of a matrix. Caley-Hamilton theorem and its use to find the inverse of a matrix. (8 hrs.)

Applications of matrices to system of linear homogenous and non-homogeneous equations. Consistency of system of linear equations. (8 hrs.)

**Unit-III(16 hrs.)**

Relation between roots and coefficients of general Polynomial equation of one variable. Transformation of equations. Horner's method. Descarte's rule of signs(without proof) to find the nature of the roots of an equation (8 hrs.) Solution of cubic equations (Cardon's method) and biquadratic equations (Ferrari's and Descarte's Method). (8 hrs.)

**Unit-IV(16 hrs. )**

De' Moivre's Theorem and its applications. (8 hrs.) Expansion of trigonometric functions (expansiion of powers of  $\sin\theta$  and  $\cos\theta$  in terms of multiples of sines and cosines and vice-versa) Summation of *sine* and *cosine* series only. (8 hrs.)

**Books Recommended:**

- H.S. Hall and S.R. Knight: Higher algebra H.M. Publications 1994
- Shanti Narayan: A Text Book of Matrices, S. Chand & Co.
- Chandrika Prasad: Text book of algebra and theory of equations, Pothishala pvt. Ltd. Allahabad.

**First Semester**

Course Code	BA/BSCMATH0102
Credits= 4	L-4,T-0,P-0
Name of the Course	Calculus
Type of the Course	(Major Core Course II)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit –I( 16 hrs.)**

$\varepsilon - \delta$  definition of limit and continuity of a function, Classification of discontinuities, Uniform continuity (its definition and examples), Indeterminate forms. (8 hrs.)

Differentiability, Successive differentiation and Leibnitz theorem, ( 8 hrs.)

**Unit –II(16 hrs.)**

Rolle's Theorem, Lagrange's Mean value Theorem. Cauchy Mean Value Theorem. Solution of inequalities by mean value theorem and approximation (linear) Lagrange and Cauchy forms by Mean Value Theorem. (8 hrs.)

Maclaurin's theorem. Taylor's theorem with Lagrange and Cauchy form of remainders. (8 hrs.)

**Unit -III(16 hrs.)**

The concavity, convexity and points of inflexion of a function. Asymptotes, (6 hrs.)

Basics of Curve tracing, curvature and radius of curvature (in Cartesian coordinates only). (10 hrs )

**Unit –IV(12)**

Reduction formulae,  $\int \sin^n x dx$ ,  $\int \cos^n x dx$ ,  $\int e^{ax} x^n dx$ ,  $\int x^n (\log x)^m dx$ ,  $\int x^n \sin x dx$ ,  $\int x^n \cos x dx$ , (6 hrs.)

$\int \sin^n x \cos^m x dx$ ,  $\int_0^{\pi/2} \sin^n x dx$ ,  $\int_0^{\pi/2} \cos^n x dx$ ,  $\int_0^{\pi/2} \sin^n x \cos^m x dx$ ,. (6 hrs.)

**Books Recommended:**

1. Shanti Narayan 'Differential Calculus' Shyam Lal Charitable Trust, Ram Nagar, New Delhi.
2. Shanti Narayan "Integral Calculus" S. Chand and Co. Ltd. Delhi, 2004.

**Second Semester**

Course Code	BA/BSCMATH0203
Credits= 4	L-4,T-0,P-0
Name of the Course	Ordinary Differential Equations
Type of the Course	(Major Core Course III)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50 Maximum Times: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit -I(16 hrs.)**

Linear differential equations. Basic theory of linear differential equations with constant coefficients. (8 hrs.).

Non homogeneous linear differential equations with constant coefficients. Method of variation of parameters to solve second degree equations. (8 hrs.)

**Unit -II(16 hrs.)**

Cauchy-Euler equation. Legendre's differential equation. System of linear differential equations with constant coefficients. (8 hrs.)

Differential operators and homogeneous linear system of differential equations (two equations in two unknown functions). (8 hrs.)

**Unit -III(16 hrs.)**

Differential equations of first order but not of first degree. Equations solvable for p, y and x. (8 hrs.).

Clairaut's equation and equations reducible to Clairaut's equation. Singular solution of differential equations (8 hrs.).

**Unit -IV(12 hrs.)**

Simultaneous equations of the form  $\frac{dx}{P} + \frac{dy}{Q} = \frac{dz}{R}$ . Total differential equations. Conditions for  $Pdx + Qdy + Rdz = 0$  to be exact. (6 hrs.)

Methods of auxiliary equations. General method of solving  $Pdx + Qdy + Rdz = 0$  by taking one variable constant. (6 hrs.)

**Books Recommended:**

1. D.A. Murray: Introductory course in differential equations, Orient Longman (India) 1967
2. S.L. Ross, Differential Equations, John Wiley and Sons.

**Second Semester**

Course Code	BA/BSCMATH0204
Credits= 4	L-4,T-0,P-0
Name of the Course	Solid Geometry
Type of the Course	(Major Core Course-IV)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests,Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(16 hrs.)**

General equation of second degree, Tangent and normal at any point of the conic. Chord of contact. Pole of a line to the conic. (8 hrs.)

Director circle of conic. Polar equation of a conic, Tangent and normal to the conic in the polar form and their geometrical properties. (8 hrs.).

**Unit-II(12 hrs.)**

Sphere. Plane section of a sphere. Sphere through a given circle. Intersection of two spheres. (6 hrs.)

Radical plane. Radical line and Radical point in spheres.

Co-axial system of spheres. (6 hrs.)

**Unit-III(16 hrs.)**

Equation of the Cone whose vertex is at the origin, Equation of a cone with a given vertex and a given conic for the base, Right circular cone, Enveloping cone and reciprocal cone, Cylinder, Right circular cylinder and enveloping cylinder, (8 hrs.)

**Unit-IV(16 hrs.)**

General equation of second degree in  $x, y$  and  $z$ , Central conicoids, principal plane, Classification of conicoids, Equation of tangent plane, Director sphere of an ellipsoid, Equation of a normal at a point, normals from a given point to a paraboloid and an ellipsoid. (8 hrs.)

Finding centre and equation of the surface referred to the centre as origin, Reduction of equation to the standard form and nature of the surface represented by it. (8 hrs.)

**Books Recommended:**

1. Shanti Narayan, Analytic Solid Geometry, S. Chand and Company, New Delhi.

**Third Semester**

Course Code	BA/BSCMATH0305
Credits= 4	L-4,T-0,P-0
Name of the Course	Sequences and Series
Type of the Course	(Major Core Course-V)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests,Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I**(12 hrs.)

Real sequences and their convergence. Theorem on limits of the sequence. Bounded and monotonic sequence and theorems based on them. (6 hrs.)

Cauchy's First and second theorem on the limit of the sequence. Cauchy's Sequence. Cauchy's general principle of convergence. (6 hrs.)

**Unit-II**(16 hrs.)

Convergence and divergence of infinite series. Positive term series, comparison test for positive term series. Cauchy's general principle of convergence of the series. (8 hrs.)

Convergence and divergence of geometric series. Harmonic series or p-series. Cauchy's condensation test (Without Proof). (8 hrs.)

**Unit-III**(16 hrs.)

Cauchy's root test, D-Alembert's Ratio test. Kummer's test Raabe's test, (8 hrs.)

De Morgan and Bertrand test Gauss test, Logarithmic test, Cauchy's integral test. (8 hrs.)

**Unit-IV**(16 hrs.)

Alternating series. Leibnitz's test. Absolute and conditional convergence. Series of arbitrary terms (8 hrs.) Abel's lemma, Abel's test Dirichlet's test. Multiplication of series and Abel's test for product of Series. (8 hrs.)

**Books Recommended :**

1. R.R. Goldberg, Real Analysis, Oxford and I.B.H. Publishing co., New Delhi, 1970.
2. S.C. Malik, Mathematical Analysis, Wiley eastern Ltd. Allahabad.
3. Shanti Narayan, A Course in Mathematical Analysis, S. Chand and Co., New Delhi.

**Third Semester**

Course Code	BA/BSCMATH0306
Credits= 4	L-4,T-0,P-0
Name of the Course	Statics and Dynamics
Type of the Course	(Major Core Course-VI)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(12 hrs.)**

Basic notion, Newton's Laws of motion system of two forces parallelogram law of forces, resultant of two coplanar forces. Resolution of forces, moment of a force.

Couple, moment of a couple, Theorems on moments of a couple. (12 hrs.)

**Unit-II(16 hrs.)**

Coplanar forces, resultant of three coplanar forces acting at a point. Algebraic method of finding the resultant of any number of coplanar concurrent forces. Theorem of resolved parts. Resultant of two forces acting on a rigid body.(10 hrs.)

Lami's theorem.  $\lambda$ - $\mu$  theorem. Theorems of moments, resultant of force and a couple. (6 hrs.)

**Unit-III(16 hrs.)**

Motion of particle with constant acceleration, acceleration of falling bodies, motion under gravity, motion of a body projected vertically upward, Projectiles, Variable acceleration, Simple harmonic motion (16 hrs.)

**Unit-IV(16 hrs.)**

Work, power and energy. Work against gravity. Potential energy of a gravitational field. Linear momentum, angular momentum, conservation of angular momentum.

Impulsive forces, principle of impulse and momentum. (16 hrs.)

**Books Recommended:**

- 1.S.L. Loney: Statics, Macmillan and Company London
2. R.S. Verma : A text book of statics, Pothishala Pvt. Ltd.
3. S.L. Loney: An elementary treatise on the dynamics of a particle and of rigid bodies, Cambridge university press, 1956.
4. M. Ray : A Text Book on Dynamics, S. Chand and co., 1989.
5. S.L. Loney: Elements of Statics and Dynamics.

**Fourth Semester**

Course Code	BA/BSCMATH0407
Credits= 4	L-4,T-0,P-0
Name of the Course	Vector Calculus
Type of the Course	(Major Core Course-VII)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Times: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit -I(12 hrs.)**

Scalar and vector product of three vectors. Product of four vectors. Reciprocal vectors. (6 hrs.) Vector differentiation, Scalar valued point functions, vector valued point functions. Derivative along a curve, directional derivatives. (6 hrs.)

**Unit -II(16 hrs.)**

Gradient of a scalar point function. Geometrical interpretation of gradient of a scalar point function ( $\text{grad}\phi$ ). Divergence and curl of a vector point function. (8 hrs.) Character of divergence and curl of a vector point function. Gradient, Divergence and Curl of sums and products and their related vector identities. Laplacian operator. (8 hrs.)

**Unit -III(16 hrs.)**

Orthogonal curvilinear coordinates. Conditions for orthogonality. Fundamental triads of mutually orthogonal unit vectors. Gradient, Divergence, Curl (8 hrs.) and Laplacian operators in terms of orthogonal curvilinear coordinators.

Cylindrical and Spherical coordinates: relation between Cartesian and cylindrical or spherical coordinates. (8 hrs.)

**Unit-IV(16 hrs.)**

Vector integration: line integral, surface integral, Volume integral (6 hrs.)

Theorems of Gauss, Green and Stokes (without proof) and the problems based on these theorems. (10 hrs.)

**Books Recommended**

1. Murray R. Spiegel: Theory and problems of Advanced calculus, Schaum Publishing company, New York.
2. Murray R. Spiegel: Vector Analysis, Schaum Publishing company, New York.
3. Shanti Narayan: A Text book of vector calculus: S Chand and Co. New Delhi.

**Fourth Semester**

Course Code	BA/BSCMATH0408
Credits= 4	L-4,T-0,P-0
Name of the Course	Real Analysis
Type of the Course	(Major Core Course-VIII)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(12 hrs.)**

Definition and examples of metric spaces, neighbourhoods, limit points, (4 hrs.)

Interior points, open and close sets, closure, interior and boundary points in a metric space and theorem based on them. (8 hrs.)

**Unit-II(16 hrs.)**

Definition and existence of Riemann integral, refinement of partitions and theorems based on them.

Darboux's theorem, condition of integrability. (8 hrs.)

The integrability of the sum and difference of integrable functions. The fundamental theorem of integral calculus. First and second mean value theorems of calculus. (8 hrs.)

**Unit-III(16 hrs.)**

Improper integrals and their convergence, (8 hrs.)

Comparison tests Abel's and Dirichlet's test of improper functions. (8 hrs.)

**Unit-IV(16 hrs.)**

Fourier series: Fourier expansion of piecewise monotonic functions, properties of Fourier coefficients Parseval's identity for Fourier series, Fourier series for even and odd functions, half range series, change of intervals. (16 hrs.)

**Books Recommended:**

1. Shanti Narayan, Theory of functions of complex variables, S. Chand & Company New Delhi.
2. T.M. Apostel, Mathematical Analysis Narosa Publishing House N.D 1985.
3. R.R.Goldberg, Mathematical Analysis, Oxford & IBH publishing House, New Delhi.
4. D.Soma Sundrem & V. Chowdhari, Course in Mathematical Analysis, Narosa Publishing House N.D 1985.
5. Shanti Narayan, A Course of Mathematical Analysis, S. Chand & Company, New Delhi.

**Fourth Semester**

Course Code	BA/BSCMATH0409
Credits= 4	L-4,T-0,P-0
Name of the Course	Abstract Algebra
Type of the Course	(Major Core Course-IX)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests,Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I**(12 hrs.)

Definition of group with examples and simple properties of groups, subgroups and theorems based on subgroups, (6 hrs.).

Centre of a group, Generation of groups, cyclic groups. (6 hrs.)

**Unit-II**(16 hrs.)

Cosets, Left and right Cosets, Normal Subgroups and their properties, Quotients groups. (12 hrs.)

Permutation of groups, Even and odd permutations. (4 hrs.)

**Unit-III**(16 hrs.)

Homomorphism of groups, Isomorphism of groups. (8 hrs.)

Automorphism of a group and

inner automorphisms of a group. (8 hrs.)

**Unit-IV**(16 hrs.)

Introduction of Rings, sub-rings, Integral Domain and fields, Characteristics of Rings.

Ring homomorphisms. (8 hrs.)

Ideals (Principal, Prime and maximal) and quotient rings. Field of quotients of an integral domain. (8 hrs.)

**Books Recommended:**

- 1.I. N. Herstein: Topics in Algebra, Wiley Eastern Company , New Delhi, 1975.
- 2.Vivek Shahi and Vikas Bist : Algebra, Narosa Publishing House.
- 3.P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul ; Basic Abstract Algebra (2<sup>nd</sup> Edition).

**Fifth Semester**

Course Code	BA/BSCMATH0510
Credits= 4	L-4,T-0,P-0
Name of the Course	Partial differential Equations
Type of the Course	(Major Core Course- X)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(12 hrs.)**

Partial differential equation of the first order in two independent variables. Formulation of first order PDE. Solution of Linear first order PDE (Lagrange's method). (6 hrs.)

Integral surfaces passing through a given curve. Surfaces orthogonal to given system of surfaces. (6 hrs.)

**Unit-II (16 hrs.)**

Solution of non-linear PDE of first order by Charpit's method.

Second order PDE equations, Classification of 2<sup>nd</sup> order PDE(8 hrs.).

Solution of linear PDE with constant coefficients. Monge's method to solve the non-linear PDE

$Rr + Ss + Tt = V$  (only). (8 hrs.)

**Unit-III(16 hrs.)**

Power series solution of differential equations and orthogonal functions. Solutions of Power series method and its basis. (8 hrs.)

Solution of Bessel and Legendre's Equations. Properties of Bessel's and Legendre's functions. (8 hrs.)

**Unit-IV(16 hrs.)**

Basic Theory of Laplace transforms (L.T.) Laplace transform solution of initial value problem. Shifting Theorems. Unit step function. Dirac- Delta function. (6 hrs.)

Differentiation and integration of Laplace transform. Inverse Laplace Transforms, Inverse Laplace Shifting Theorem. Differentiation and Integration of Inverse Laplace Transforms. Convolution Theorem. (10 hrs.)

**Book Recommended**

1. J.N. Sharma and Kehar Singh, Partial Differential Equations for Engineers and Scientists. Narosa Publishing House.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and sons. New York.
3. S. L. Ross, Differential Equations, John Wiley Student Edition, Third Edition,2004.

**Fifth Semester**

Course Code	BA/BSCMATH0511
Credits= 4	L-4,T-0,P-0
Name of the Course	Linear Algebra
Type of the Course	(Major Core Course-XI)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I**(12 hrs.)

Vector Space, Subspaces, Sum and Direct sum of Subspaces, Linear span. Linearly independent and linearly dependent subsets of a vector space. Finitely generated vector space . (6 hrs.) Existence theorem for basis of finitely generated vector space(statement only), Invariance of number of elements of basis sets. Dimension of vector space. (6 hrs.)

**Unit-II**(16 hrs.)

Homomorphism and Isomorphism of vector spaces. Linear transformation and their algebra. Representation of transformation by matrices. (8 hrs.)  
Linear functionals. Null space and range space of a linear transformation, rank and nullity theorem. (8 hrs.)

**Unit-III**(16 hrs.)

Algebra of linear transformations. Minimal polynomial of linear transformation. Singular and non-singular linear transformations. (8 hrs.)  
Matrix of linear transformation, change of basis, eigenvalues and eigenvectors of a linear transformation. (8 hrs.)

**Unit-IV**(16 hrs.)

Inner product Spaces. Cauchy-Schwartz inequality. Orthogonal vectors. Orthogonal complements, Orthonormal sets and basis. (10 hrs.)  
Bessel's inequality for finite dimensional vector spaces. Gram-Schmidt orthogonalization process. (6 hrs.)

**Books Recommended:**

1. I.N. Herstein: "Topics in Algebra", Wiley Eastern Company , New Delhi, 1975.
2. Hoffman and R. Kunze; Linear Algebra, 2<sup>nd</sup> Edition, Prentice Hall of India, Delhi.
3. Vivek Shahi and Vikas Bist : Algebra, Narosa Publishing House.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul ; Basic Abstract Algebra (2<sup>nd</sup> Edition)

**Fifth Semester**

Course Code	BA/BSCMATH0512
Credits= 4	L-4,T-0,P-0
Name of the Course	Complex Analysis
Type of the Course	(Major Core Course-XII)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(12 hrs.)**

Function of complex variable, Trigonometric, exponential, Euler's Theorem, Direct and Inverse hyperbolic functions, relations between trigonometric and hyperbolic functions, Logarithm of a complex quantity (12 hrs.)

**Unit-II(16 hrs.)**

Analytic function, harmonic function, determination of conjugate function (8 hrs.)  
Milne-Thompson method, Cauchy Riemann equations (Cartesian and polar forms). (8 hrs.)

**Unit-III(16 hrs.)**

Conformal mappings. Necessary and sufficient conditions for  $w=f(z)$  to represent a conformal mapping (Statement only). Some elementary transformation like translation, rotation, magnification and Magnification and rotation (6 hrs)

Mobius Transformations. Resultant of two bilinear transformations. Every bilinear transformation is the resultant of elementary transformation with simple geometric properties, Cross ratio (10 hrs)

**Unit-IV(16 hrs.)**

Fixed points, Inverse points with respect to a circle, Complex integrations, (8 hrs.)  
Definite integral, Cauchy Theorem and Cauchy's integral formula. (8 hrs)

**Books recommended :**

1. Shanti Narayan: "Theory of functions of complex variables, S.Chand and Co., New Delhi.
2. T.M. Apostol : Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
3. R.R. Goldberg : Real Analysis, Oxford and IBH Publishing Co., , New Delhi, 1970.
4. D. Somasundram and B. Chaudhary; A first course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997.
5. Shanti Narayan; A first course in Mathematical Analysis, S.Chand and Co., New Delhi.

**Sixth Semester**

Course Code	BA/BSCMATH0613
Credits= 4	L-4,T-0,P-0
Name of the Course	Advanced Calculus
Type of the Course	(Major Core Course XIII)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50 Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(16 hrs.)**

Limit and continuity of functions of two variables, partial differentiation change of variables, Jacobians (6 hrs)

Maxima, Minima and Saddle points of functions of two variables. Lagrange's multiplier method (10 hrs.).

**Unit-II(16 hrs.)**

Quadrature, rectification. Evaluation of area and volume by double and triple integral respectively(Cartesian and parametric forms) (8 hrs.).

Beta and Gamma functions and their properties. Problems based on Beta and Gamma functions (8 hrs.).

**Unit-III(12 hrs.)**

Partial Derivation and differentiability of real valued functions of two variables. Schwartz and young's Theorem (6 hrs.).

Implicit function Theorem (case of two variables). Euler's Theorem on Homogenous functions. Taylor's Theorem for functions of two variables (6 hrs.).

**Unit-IV(16 hrs.)**

Calculus of variations: Variational problems with fixed boundaries. Euler's equation for functional containing first order derivatives and one independent variable. Extremals (8 hrs.).

Functionals dependent on higher order derivatives. Functionals dependent on more than one independent variables. Variational problems in parametric form (8 hrs.).

**Books Recommended**

1. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Pvt. Ltd. Publishers.
2. Shanti Narayana, Intergal Calculus, S. Chand and Co. New Delhi.
3. A.S. Gupta, Calculus of variations with applications, Prentice Hall of India Pvt. Ltd New Delhi.
4. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Pvt. Ltd. Publishers.

**Sixth Semester**

Course Code	BA/BSCMATH0614
Credits= 3	L-3,T-0,P-0
Name of the Course	Numerical Analysis
Type of the Course	(Major Core Course-XIV)
Number of hrs required for this course	45 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	45(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**The students will be allowed to use non-programmable scientific calculator during the examination.**

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I (16 hrs.)**

Solution of equation: Bisection Method, Secant Method, Regula – Falsi Method and Newton’s Method, Linear equations: Gauss – Elimination Method, Jacobi Method, Gauss- Seidal Method.

**Unit-II (16 hrs.)**

Ordinary Differential Equations; Euler’s Method, Single- step Method, Runge-Kutta’s IInd and IVth order method, Multi -step Method, Milne-Simpson Method.

**Unit-III (16 hrs.)**

Interpolation: Lagrange and Newton Interpolation, Newton’s – Gregory Forward interpolation formula, Divided difference, Newton’s divided differences formula,

**Unit-IV (12hrs.)**

Numerical Integration: Newton – Cote’s 1/3 rule, Simpson 3/8<sup>th</sup> rule, Gauss Quadrature formulas.

**Books Recommended:**

1. E. Balagurusamy, Numerical Methods, Tata Mc-Graw Hill Pub. C. Ltd, New Delhi 1999.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods Scientific and Engineering Computation, New Age International Publishers, 4<sup>th</sup> Edition, New Delhi, 2003.

**Sixth Semester**

Course Code	BA/BSCMATH0614(P)
Credits= 1	L-0,T-0,P-1
Name of the Course	Numerical Analysis Lab-1
Type of the Course	(Lab Course-I)
Number of hrs required for this course	30 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz,Seminar and Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 2 hrs.
Practical time	30(One Hour Each) or 15(two hour each) practical sessions

**Instructions for paper setter / candidates**

Laboratory examination will consist of three parts:

(i) Performing of practical exercises assigned by the examiner (34 marks). (ii) Viva voce examination (10 marks) (iii) Practical Record File prepared by a candidate during the semester (6 marks)

Viva-voce examination will be related to the practical performed and Practical Record File executed by the candidate related to the paper during the course of the semester. A candidate will prepare a practical record file of the programs developed during the course of the semester which shall be evaluated at the time of final practical examination. In the practical examination **three problems** will be given and a candidate shall have to develop algorithm, source code and test cases **for two of them**. The weightage of credit for each question in the practical examination shall be as: algorithm (8 marks), source code (6 marks) and test case checks (3 marks).

**Course Detail:** The students will be familiarised with the basic input and output devices, storage devices. Truncation and round off errors, Absolute and relative errors etc. shall be discussed in the context of computing on computers. (3 hrs.).

List of Programs (Practical) to be developed in Computer Lab using any one of the programming languages C / C++ / Scilab/ Fortran/MATLAB. The candidates are required to develop and run TEN programs selecting at least three programs from each Unit out of the listed below programs, in which the candidate should also be encouraged to use Functions, Arrays, FILE opening, FILE reading and FILE writing commands in the programs.

**List of Programs (Practical)****UNIT-I**

1. Bisection Method
2. Regula Falsi Method
3. Newton Raphson Method
4. Secant Method

**UNIT-II**

5. Gauss elimination Method
6. Gauss – Seidal Method
7. Jacobi method
8. Difference table generation

**UNIT-III**

9. Trapezoidal rule
10. 1/3 Simpson rule
11. Newton – forward methods of interpolation
12. Lagrange's method of interpolation
13. Euler Method of Solving Differential equation
14. 4<sup>th</sup> order Runge – Kutta Methods of solving differential equation.

The above listed programs are based on the course contents of **Numerical Analysis** (BA/BSCMATH0614)

**Books Recommended**

- 1.E. Balagurusamy, 'Numerical Methods', Tata McGraw Hill Co. New Delhi , 2004
2. C Xavier, FORTRAN 77 and Numerical Methods , New Age International publications, Delhi,India.
3. Yashwant Kanetkar, Let us C, BPB Publications.

**Fourth Semester**

Course Code	BA/BSCMATH0415
Credits= 4	L-4,T-0,P-0
Name of the Course	Hydrostatics
Type of the Course	(Core Elective course-I)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit – I(12 hrs.)**

Pressure equation. Condition of equilibrium. Lines of force. Homogeneous and Heterogeneous fluids. Elastic fluids. Surface of equal pressure.

**Unit– II(16 hrs.)**

Fluid at rest under action of gravity. Rotating fluids. Fluid pressure on plane surfaces, Centre of pressure. Resultant pressure on curved surfaces.

**Unit – III(16 hrs.)**

Equilibrium of floating bodies. Curves of buoyancy. Surface of buoyancy, Stability of equilibrium of floating bodies. Meta center.

**Unit– IV(16 hrs.)**

Work done in producing a displacement. Vessel containing liquid. Gas Laws. Mixture of gases. Internal energy. Adiabatic expansion. Work done in compressing a gas. Isothermal atmosphere. Connective Equilibrium.

**REFERENCES:**

1. W.H. Besant and A.S. Ramsey, A Treatise on Hydromechanics, G. Bell.

**Fourth semester**

Course Code	BA/BSCMATH0516
Credits= 4	L-4,T-0,P-0
Name of the Course	Mechanics
Type of the Course	(Core Elective Course-II)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(12 hrs.)**

Analytic condition of equilibrium of coplanar forces, Virtual work.

**Unit-II(16 hrs.)**

Forces in three dimensions, Wrenches, Null lines and Null planes. Stable and Unstable equilibrium.

**Unit-III(16 hrs.)**

Motion on rough curves, Tangential and normal accelerations. Motion in resisting medium, Velocity along radial and transverse directions,

**Unit-IV(16 hrs.)**

Central orbit. Central force, differential equation of central orbit in polar coordinates, Kepler's laws of planetary motion(statement only) and the problems based on them.

**Books Recommended:**

1. S.L. Loney, An elementary Treaties on the Dynamics of a particle and of rigid bodies", A.I. T. S. Publications, 2003.
2. S.L. Loney, An elementary Treaties on Statics, A.I.T. S. Publishers and distributors, Delhi, 2003 .

**Sixth Semester**

Course Code	BA/BSCMATH0617
Credits= 4	L-4,T-0,P-0
Name of the Course	Elementary Number Theory
Type of the Course	(Open Elective Course-I)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments,Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50 Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(12 hrs.)**

The Fundamental theorem of Arithmetic: Introduction, divisibility, greatest common divisor(g.c.d),prime numbers, the fundamental theorem of arithmetic, the Euclidean algorithm, the g.c.d. of more than two numbers.

**Unit-II(16 hrs.)**

Arithmetical Functions: Introduction, the Mobius function  $\mu(n)$ , The Euler totient function  $\varphi(n)$ , a relation connecting functions  $\varphi$  and  $\mu$ . A product formula for  $(n)$ , the Dirichlet product of arithmetical functions. Dirichlet inverses and the Mobius inversion formula.

**Unit-III(16 hrs.)**

Congruences: definition and basic properties of congruences, residue classes and complete residue systems. Linear congruences, reduced residue systems and the Euler-Fermat theorem. Polynomial congruence modulo p. Lagrange's theorem and its applications. Simultaneous linear congruences, the Chinese remainder theorem and its applications.

**Unit-IV(16 hrs.)**

Quadratic Residues and the Quadratic Reciprocity Law: Quadratic residues, Legendre's symbol and its properties. Gauss' lemma, Gauss' quadratic reciprocity law and its applications.

**Books recommended:**

1. Tom M. Apostol, Introduction to Analytic Number Theory, Narosa Publishing House, 1997.

**Sixth Semester**

Course Code	BA/BSCMATH0618
Credits= 4	L-4,T-0,P-0
Name of the Course	Discrete Mathematics
Type of the Course	(Open Elective Course-II)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz,Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50 Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit – I(18 hrs.)**

**Mathematical Logics: Statements, Connectives:** Negation, Conjunction, Disjunction, Statement Formulas and Truth tables, Logical Capabilities of Programming Languages, Conditional and Biconditional, Well-formed Formulas, Tautologies, Equivalence of Formulas, Duality Law, Tautological Implications, Formulas with Distinct Truth tables, Functionally Complete Sets of Connectives, Other Connectives, Two-state Devices and Statement Logic. **Normal Forms:** Disjunctive Normal Forms, Conjunctive Normal Forms, Principal Disjunctive Normal forms, Principal Conjunctive Normal forms, Ordering and uniqueness of Normal Forms, Completely Parenthesized Infix Notation and Polish Notation.

**Unit–II(14 hrs.)**

**Relations and Functions: Relations and ordering:** Relations, Properties of Binary Relations in a set, Relation Matrix and graph of a relation, Partition and Covering of a set, Equivalence Relations, Compatibility Relations, Composition of Binary relations, Partial Ordering, Partially Ordered Set. **Functions:** Definition and Introduction, Composition of Functions, Inverse Functions, Binary and n-ary Operations, Characteristic Function of a set.

**Unit – III(16 hrs.)**

**Lattices:** Lattices as partially ordered Sets, Some properties of Lattices, Lattices as Algebraic Systems, Principle of duality, Basic properties of systems defined by lattices, sublattices, Distributive and complemented lattices. Direct Product and Homomorphism.

**Unit – IV(12 hrs.)**

**Boolean Algebra:** Definition and Examples, Subalgebra, Direct product and Homomorphism.

**Boolean Functions:** Boolean Forms and Free Boolean Algebras, Values of Boolean Expressions and Boolean Functions, Representation of Boolean Functions, Minimization of Boolean Functions.

**Text Books:**

1. C. L. Liu, Elements of Discrete Mathematics, 3<sup>rd</sup> Edition, Tata McGraw-Hill, 2008.
2. J. P. Tremblay, R. Manohar, Discrete Mathematical Structures with applications to computer Science, McGraw-Hill.

**Sixth semester**

Course Code	BA/BSCMATH0619
Credits= 4	L-4,T-0,P-0
Name of the Course	Statistics
Type of the Course	(Open Elective Course-III)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(16 hrs.)**

Measures of Dispersion, skewness and Kurtosis; Bivariate data distribution, Scatter diagram, Principle of least square and its application in fitting of curves.

**Unit-II(16 hrs.)**

Correlation, Correlation of ranks, Correlation and linear regression. A random variable, Concept of mathematical expectation and its simple properties. Moments and moment generating function.

**Unit-III(16 hrs.)**

Discrete and continuous distributions, Binomial, Poisson's, geometric and normal distributions and their properties.

**Unit-IV(12 hrs.)**

Basics of sampling theory. Sampling distributions, test of significance, sampling of variables and attributes. Chi-square test for the population variance and goodness of fit. Student's t-distribution test for single mean and difference of two means. F-test for the equality of two population variances.

**Books Recommended:**

1. A.M. Mood and F.A. Graybil; Introduction to theory of Statics: Mc Graw Hill Book Co.1968.
2. V.K. Rohtagi, An introduction to Probability and Mathematical Statistics, John Wiley and sons, 1976.
3. J.N. Kapur and H.C. Saxena : Mathematical Statistics, S.Chand and Co., New Delhi.
4. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Co.
5. H. C. Taneja: Statistical Methods for Engineering and Sciences, I. K. Pvt. Int.,2011.

**Sixth Semester**

Course Code	BA/BSCMATH0620
Credits= 4	L-4,T-0,P-0
Name of the Course	Mathematical Modeling
Type of the Course	(Open Elective Course-IV)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit –I(12 hrs.)**

**Mathematics Modeling:** Simple situations requiring mathematical modeling, techniques of mathematical modeling, classifications of mathematical modeling, characteristics of mathematical models. Mathematical modeling through geometry, algebra, trigonometry and calculus. Limitations of methodical modeling.

**Unit-II(16 hrs.)**

**Mathematics modeling through ordinary differential equations (ODE)of first order:** Mathematical modeling through ODE, linear growth and decay model, non-linear growth and decay models, compartment models, mathematical modeling in dynamics through first order ODE.

**Mathematics modeling through Systems of ODE of first order:** Mathematical modeling in population dynamics, mathematical modeling of epidemic, compartment model through system of ODE.

**Unit-III(16 hrs.)**

Mathematics modeling in economics, in medicine, Arms race, Battles, international trade in terms of system of ODE and dynamic through ordinary differential equations.

**Mathematical modeling through ODE of second order:** Mathematical Modeling of circular motion, Planetary motions and motions of satellite.

**Unit-IV(16 hrs.)**

**Mathematical modeling through difference equations:** The need, basic theory, Modeling in Economics and finance, Modeling in population dynamics and Genetics, Modeling in probability theory. Examples of Mathematical modeling through difference equations.

**Books Recommended:**

1. J.N. Kapur: Mathematical modeling Wiley Eastern limited, 1990(Chapter I – V)

**Sixth Semester**

Course Code	BA/BSCMATH0621
Credits= 4	L-4,T-0,P-0
Name of the Course	Linear Programming
Type of the Course	(Open Elective Course-V )
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz,Seminar and Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I(16 hrs.)**

Mathematical Preliminaries: Matrix and Basic Operations on Matrices (Addition, subtraction, multiplication and Inverse calculation) (10 hrs.)

Rank of a matrix, Determinant of a matrix, Vectors and linear dependence/independence of vectors and Basis (6 hrs.)

**Unit-II(12 hrs.)**

Introduction to Linear Programming (LP). Mathematical Modelling of a Linear Programming problem(LPP),Graphical method to solve a LPP, Simplex Method (12 hrs.).

**Unit-III(12 hrs.)**

Big M - Method and Two-Phase Method to solve a LPP (8 hrs.)

Concept of Duality in LP and formulation of Dual of a Primal LPP ((4 hrs.).

**Unit-IV (20 hrs.)**

LPP Extensions: Assignment Problem – Hungarian Algorithm (Minimization problem),

Unbalanced Assignment Problem(5 hrs.).

Transportation problems (TP)– Matrix form of TP., Unbalanced TP (3 hrs.)

Initial Basic Feasible Solution(IBFS) by using North West Corner Method, Least Cost Method and Vogel's Approximation Method(5 hrs.)

Degeneracy in TP(3 hrs.)

UV-Method for Checking the Optimality of IBFS(4 hrs.).

**Text Book:**

1. Kanti Swarup, P. K. Gupta and Man Mohan: Operations Research, Sultan Chand & Sons, New Delhi

**Reference Books:**

1. Kalavathy, S., Operations Research, Vikas Publishing House, New Delhi.
2. Sharma, S.D., Operations Research, Kedar Nath Ram Nath & Co., Meerut.
3. Sharma, J.K., Operations Research: Theory and Applications, Macmillan India Ltd., New Delhi.

**Sixth Semester**

Course Code	BA/BSCMATH0622
Credits= 4	L-4,T-0,P-0
Name of the Course	Financial Mathematics
Type of the Course	(Open Elective Course-VI)
Number of hrs required for this course	60 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz,Seminar and Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 3 hrs.
Lectures to be Delivered	60(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and UNIT-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I (12 hrs.)**

Financial management- A overview. Nature and scope of Financial Management.

Goals of Financial Management and main decisions of Financial Management.

**Unit-II(16 hrs.)**

Difference between Risk, Speculation and Gambling. Time value of Money-Interest Rate and discount rate.

Present value and future value-discrete case as well as continuous compounding case. Annuities and its kinds.

**Unit-III(16 hrs.)**

Meaning return, Return as Internal Rate of return (IRR). Numerical Methods like Newton Raphson method to calculate IRR. Measurement of Returns under uncertaining situations. Meaning of risk. Difference between risk and uncertainty.

**Unit-IV(16 hrs.)**

Types of risks. Measurement of risk. calculation of security and port- folio Risk and Return- Markowitz Model. Sharpe's Single Index Model-Systematic Risk and unsystematic Risk. Taylor Series and Bond valuation. Calculation of duration and Convexity of bonds. Financial Derivatives- Futures. Forward, Swaps and Options. Call and Put Options.

**REFERENCES:**

1. Aswath Damodaran, Corporate finance-theory and practice, John Waley and Sons, Inc.
2. John C. Hull, Options, Futures and Other Derivatives, Prentice Hall of India Pvt. Ltd.
3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.

**First/Second/Third Semester**

Course Code	BA/BSCMATH01/02/03 23
Credits= 3	L-3,T-0,P-0
Name of the Course	Basic Mathematics for all
Type of the Course	Compulsory Course-I (Skill based)
Number of hrs required for this course	45 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50      Maximum Time: 3 hrs.
Lectures to be Delivered	45(One Hour Each)

**Instructions**

**Instructions for paper setter:** The question paper will consist of five Sections of 50 marks. **Section A** will be **Compulsory** for all and shall consist of 12 questions of 18 marks (each of one and half marks) of multiple choice type, true/false type, statement of theorem or fill in the blanks type etc. This section will be distributed over the whole syllabus uniformly. Sections B, C, D and E of the question paper shall be based on units, Unit-I, Unit-II, Unit-III and Unit-IV, respectively. In each of these sections two questions will be set and the students shall have to attempt one question from each of these sections. Each question in Sections B, C, D and E shall be of 8 marks each.

**Instructions for Candidates:** Candidates are required to attempt five questions in all. All parts of question in Section A shall be Compulsory. The students are required to select one question from the questions in each of the Sections B, C D and E of the question paper.

**Unit-I (12 hrs)**

Idea of functions, Idea of limit and Continuity, Differentiation of elementary functions, Applications of derivatives to determine the Increasing and decreasing behaviour of a function, to find the maxima and minima of a function.

**Unit-II(12 hrs)**

Integration of some elementary functions, integration by parts, integration by substitution of some simple integrals.

Solutions of linear and quadratic equations, Solutions of simultaneous linear equations up to three variables only.

**Unit-III(11 hrs)**

Matrices, Types of Matrices, Matrix as an array representing the system of equations, Basic operations on matrices like addition, subtraction, multiplication, and transpose.

Determinants and evaluation of determinants (up to 3x3 order).

**Unit-IV(10 hrs)**

Graphs of linear inequalities, Introduction to linear programming problems and their solutions by graphical method only.

**Book Recommended:**

1. Timothy M. Hagle: Basic Math for Social Scientists, Sage Publications, New Delhi.

**First/Second/Third Semester**

Course Code	BA/BSCMATH01/02/03 24
Credits= 2	L-2,T-0,P-0
Name of the Course	Basic Numeracy, Logical Reasoning and Data Interpretation
Type of the Course	GI & H-1
Number of hrs required for this course	30 hrs.
Continuous Comprehensive Assessment: Based on Minor Tests(2), Class tests, Assignments, Quiz, Seminar and Attendance. (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:50
Semester Term End Examination	Max Marks: 50    Maximum Time: 2 hrs.
Lectures to be Delivered	30(One Hour Each)

The basic objective of offering this course is to equip the students for mathematical analysis of data for drawing of quantitative inferences from given data and enable them to prepare for the logical reasoning , numeracy and data interpretation component in papers of **banking** and other **competitive examinations**.

**Instructions**

**Instructions for paper setter:** The question paper shall consist of 50 questions. Each question shall be of one mark each and shall be of objective/multiple choice type. The questions will be uniformly distributed over the whole syllabus from all the units.

**Instructions for Candidates:** Candidates are required to attempt all questions in 2 hrs.

**UNIT-I (8 hrs.)**

Introduction to number systems: Natural numbers, Integers, rational numbers, real numbers, complex numbers.

Elements of set theory: Set, Types of set with examples. Representation of sets.

Basic operations on sets ( union, intersection, complementation). Venn diagram.

Verbal reasoning: Logical Venn Diagrams; Mathematical Operations-Problem solving by substitution, Interchange of signs and numbers, Logical sequences of words.

**UNIT-II (7 hrs.)**

Number series, letter series, coding-decoding, analogy test, Relationship problems, Calendar problems.

Arithmetical reasoning: number series completion, calculation based problems, data based problems, problem on ages, work and time problems, percentage problems.

**UNIT-III (7 hrs.)**

Logical deductions: logical reasoning, logical deductions, two-premise and three-premise arguments; Statement-Arguments; Statement-Assumptions; Statement-Courses of Action; Statement-Conclusions.

**UNIT-IV (8 hrs.)**

Organisation of data: Frequency table, Grouping.

Pictorially displaying data: dot plots, bar graphs, line graphs, pie charts.

Data interpretation: Numerical based on analysis of data presented in tabular, bar chart, pie-chart or line graph.

**Suggested Books:**

R.S. Aggarwal A modern approach to Verbal and non-verbal reasoning , S. Chand and Co.

UGC NET/JRF/SLET General Paper-1, Arihant Publications India.

J.K. Chopra, CSAT CAPSULE General studies Paper-II, Unique Publishers Delhi, 2013.

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