DEPARTMENT OF APPLIED MATHEMATICS
Four year B.S. Honours Programme

Degree Requirements: Successful completion of 139 credits

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>Major Courses</td>
<td>129</td>
</tr>
<tr>
<td>Minor Courses</td>
<td>10</td>
</tr>
<tr>
<td>Theory Courses</td>
<td>106</td>
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<tr>
<td>Lab Courses</td>
<td>12</td>
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<td>Honours Project</td>
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<tr>
<td>Viva Voce</td>
<td>8</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>139</strong></td>
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</table>

(Minor Subjects: Statistics, Physics)

Year-wise Class-Load

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>33 credits</td>
</tr>
<tr>
<td>Second</td>
<td>35 credits</td>
</tr>
<tr>
<td>Third</td>
<td>35 credits</td>
</tr>
<tr>
<td>Fourth</td>
<td>36 credits</td>
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<table>
<thead>
<tr>
<th>Year</th>
<th>Total Credits</th>
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</thead>
<tbody>
<tr>
<td>First Year</td>
<td>33 credits</td>
</tr>
<tr>
<td>Major Courses</td>
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<tr>
<td>Minor Courses</td>
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<tr>
<td>Math Lab</td>
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</tr>
<tr>
<td>Viva Voce</td>
<td>2 credits</td>
</tr>
<tr>
<td>Second Year</td>
<td>35 credits</td>
</tr>
<tr>
<td>Major Courses</td>
<td>28 credits</td>
</tr>
<tr>
<td>Minor Courses</td>
<td>2 credits</td>
</tr>
<tr>
<td>Math Lab</td>
<td>3 credits</td>
</tr>
<tr>
<td>Viva Voce</td>
<td>2 credits</td>
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<td>Viva Voce</td>
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<tr>
<td>Fourth Year</td>
<td>36 credits</td>
</tr>
<tr>
<td>Major Courses</td>
<td>28 credits</td>
</tr>
<tr>
<td>Math Lab</td>
<td>3 credits</td>
</tr>
<tr>
<td>Honours Project</td>
<td>3 credits</td>
</tr>
<tr>
<td>Viva Voce</td>
<td>2 credits</td>
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</table>
List of Major Courses

First Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>AMTH 101</td>
<td>Fundamentals of Mathematics and Boolean Algebra</td>
<td>4</td>
</tr>
<tr>
<td>AMTH 102</td>
<td>Applied Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>AMTH 103</td>
<td>Coordinate and Vector Geometry</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 104</td>
<td>Applied Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 105</td>
<td>Fundamentals of Computer</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 106</td>
<td>FORTRAN Programming</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 150</td>
<td>Math Lab I (Mathematica)</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 199</td>
<td>Viva Voce</td>
<td>2</td>
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</table>

Second Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AMTH 201</td>
<td>Mathematical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 202</td>
<td>Multivariate and Vector Calculus</td>
<td>4</td>
</tr>
<tr>
<td>AMTH 203</td>
<td>Ordinary Differential Equations with Modeling</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 204</td>
<td>Advanced Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 205</td>
<td>Numerical Methods I</td>
<td>3</td>
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<tr>
<td>AMTH 206</td>
<td>Discrete Mathematics</td>
<td>3</td>
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<tr>
<td>AMTH 207</td>
<td>Principles of Economics</td>
<td>3</td>
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<tr>
<td>AMTH 208</td>
<td>Principles of Statistics</td>
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<tr>
<td>AMTH 209</td>
<td>Mathematical Statistics</td>
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<tr>
<td>AMTH 250</td>
<td>Math Lab I (Fortran)</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 299</td>
<td>Viva Voce</td>
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Third Year

<table>
<thead>
<tr>
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<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AMTH 301</td>
<td>Complex Variables and Fourier Analysis</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 302</td>
<td>Theory of Numbers</td>
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</tr>
<tr>
<td>AMTH 303</td>
<td>Partial Differential and Integral Equations</td>
<td>4</td>
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<tr>
<td>AMTH 304</td>
<td>Mathematical Methods</td>
<td>4</td>
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<tr>
<td>AMTH 305</td>
<td>Numerical Methods II</td>
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<tr>
<td>AMTH 306</td>
<td>Mechanics</td>
<td>3</td>
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<tr>
<td>AMTH 307</td>
<td>Hydrodynamics</td>
<td>3</td>
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<tr>
<td>AMTH 308</td>
<td>Introduction to Financial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 309</td>
<td>Optimization Techniques</td>
<td>4</td>
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<tr>
<td>AMTH 350</td>
<td>Math Lab III</td>
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<tr>
<td>AMTH 399</td>
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Fourth Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>AMTH 401</td>
<td>Applied Analysis</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 402</td>
<td>Fluid Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 403</td>
<td>Physical Meteorology</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 404</td>
<td>Elementary Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 405</td>
<td>Differential Geometry and Tensor Analysis</td>
<td>4</td>
</tr>
<tr>
<td>AMTH 406</td>
<td>Asymptotic Analysis and Perturbation Methods</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 407</td>
<td>Stochastic Calculus</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 408</td>
<td>Econometrics</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 409</td>
<td>Actuarial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 410</td>
<td>Heat Transfer</td>
<td>3</td>
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</table>

Several Courses from AMTH 408 to AMTH 430 will be offered as per the decision of the academic committee. Among those two courses will be chosen by the students.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AMTH 411</td>
<td>Modern Astronomy</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 412</td>
<td>Quantum Theory and Special Relativity</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 413</td>
<td>Mathematical Modelling in Biology and Physiology</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 414</td>
<td>Mathematical Neuroscience</td>
<td>3</td>
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<tr>
<td>AMTH 415</td>
<td>Industrial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 416</td>
<td>Computational Science and Engineering</td>
<td>3</td>
</tr>
<tr>
<td>AMTH 430</td>
<td>Special Topics</td>
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<tr>
<td>AMTH 450</td>
<td>MATH LAB IV</td>
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<td>AMTH 460</td>
<td>Honours Project</td>
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<tr>
<td>AMTH 499</td>
<td>Viva Voce</td>
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</table>
Detailed Syllabi

AMTH 101: Fundamentals of Mathematics and Boolean Algebra 4 credits

7. Elementary number theory: Divisibility. Fundamental theorem of arithmetic. Congruence’s (basic properties only).

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 4 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered including at least one from ‘Boolean Algebra’.

References
1. S. Lipschutz, Set Theory, Schaum’s Outline Series.
4. P.R. Halmos, Naive Set Theory.

AMTH 102: Applied Calculus I 4 credits

A. Differential Calculus
1. Functions and their graphs: polynomial and rational functions, logarithmic and exponential functions, trigonometric functions and their inverses, hyperbolic functions and their inverses, combination of such functions.
4. Power series expansion: Taylor’s theorem with general form of the remainder; Lagrange’s and Cauchy’s forms of the remainder. Taylor’s series. Maclaurin series. Differentiation and
integration of series. Validity of Taylor expansions and computations with series. Indeterminate forms.
5. Applications: Physical, Biological, Social Sciences, Business and Industry.

**B. Integral Calculus**
3. Improper integrals. Improper integrals of different kinds. Gamma and Beta functions.
4. Graphing in polar coordinates: Tangents to polar curves. Area and arc length in polar coordinates.

**Evaluation**: Incourse Assessment 30 marks, Final examination (Theory, 4 hours) 70 Marks.
Eight questions of equal value will be set, four from each group, of which five are to be answered, taking at least two questions from each group.

**References**
1. H. Anton et al., Calculus with Analytic Geometry.
5. Stefan Waner and Steven Costenoble, Applied Calculus.
6. G. Strang, Calculus.

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**AMTH 103: Coordinate and Vector Geometry**

**3 credits**

A. Two-dimensional Geometry

B. Three-dimensional Geometry
4. Planes, straight lines and conicoids (basic definitions and properties only).

C. Vector Geometry

**Evaluation**: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

Eight questions of equal value will be set in which 3 from A, 3 from B and 2 from C. Any five questions are to be answered by taking at least one from each group.

**References**
AMTH 104: Applied Linear Algebra  

3. Vector Spaces: Review of geometric vectors in \( \mathbb{R}^2 \) and \( \mathbb{R}^3 \) space. Norms vectors in \( \mathbb{R}^n \) and \( \mathbb{C}^n \). Vector space and subspace. Sum and direct sum of subspaces. Linear independence of vectors, basis and dimension of vector spaces. Row spaces, column spaces and null spaces, rank and nullity of a matrix. Solution spaces of systems of linear equations.
6. Applications: Solving problems in physical, social and applied sciences.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours ) 70 Marks. Eight questions of equal value will be set, of which any five are to be answered.

References
2. S. Lipshutz, Linear Algebra, Schaum’s Outline Series.
4. D. Lay, Linear Algebra with Applications.
5. G. Strang, Linear Algebra with Applications.
6. Peter J. Olver and Cheri Shakiban, Applied Linear Algebra

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AMTH 105: Fundamentals of Computer  

1. Introduction: Brief history and types of computers, application areas, Working principle of a computer system, Single and multiuser systems.
3. Software: Classification, System software, Operating system concepts, components and basic functions of DOS, Windows, UNIX and Linux operating systems. Application software, database, spreadsheet and word-processing software, open source software, firmware etc. System software and Operating systems: Introduction, processing and services, Popular operating systems. Database Concepts: Introduction, Database software, database structures, database access and development. Computer networks and Internet: basic concepts on LAN, WAN and Internet systems, Internet services and protocols, E-mail and WWW, Intranet and extranet.
4. IT applications: Multimedia basics and Multimedia systems, Electronic Commerce, Access, Security and Privacy. Computer viruses, and protections, Antivirus programs, software troubleshooting and
maintenance. Selection of computers: different types of hardware configuration, hardware selection, software and cost consideration. Software installation: Low level and high level formatting, Harddisc partitioning, heterogeneous operating system installation, application software installation and setup.

5. Introduction to system analysis: system development life cycle, case studies, system conversion techniques, system audits.


**Evaluation:** Incourse Assessment 30 marks, Final examination (3 hours) 70 marks.
**Eight** questions of equal value will be set of which any **five** are to be answered.

**Reference**

**AMTH 106: FORTRAN Programming**  
3 credits

1. Introduction to personal computers.
2. Number System: Binary to Decimal and Decimal to Binary, other systems – octal, hexadecimal, etc.
3. Fundamentals of Computer Programming- Introduction to FORTRAN – how to write, process and run program
5. Programming in FORTRAN: Syntax and semantics, data types and structures, input/output, loops, decision statements, arrays, user-defined functions, subroutines and recursion.

Classes: Theory (2 hours/week), Lab (At least 10 assignments).

Evaluation: Internal Assessment (Laboratory work) 30 Marks, Final examination (Theory, 3 hours). 70 Marks. Eight questions of equal value will be set of which any five are to be answered.

**References**
1. Stephen J Chapman, Introduction to FORTRAN 90/95
2. Programming in Fortran, Schaum’s Outline Series.

**AMTH 150: MATH LAB I**  
3 credits

Introduction to the computer algebra package MATHEMATICA.
Problem solving in concurrent courses (e.g., Calculus, Linear Algebra and Geometry) using MATHEMATICA.
Lab Assignments: There are at least 15 lab assignments

Evaluation: Internal Assessment (Laboratory works) 40 Marks. Final examination (Lab, 3 hours) 60 Marks.

**AMTH 199: Viva Voce**  
2 credits
Viva Voce on courses taught in First Year.
AMTH 201: Mathematical Analysis  3 credits

1. Real number system: Supremum and infimum of a set. Cluster (limit) points; the completeness axiom, Dedekind’s theorem and Bolzano-Weierstrass theorem (No proof). Open and closed sets, interior, exterior and boundary of a set, cluster point and derived set.

2. Infinite sequences: Sequences of real number, Convergence, Monotone sequences, subsequences, Cauchy’s general principle of convergence, some important sequences.


4. Limit, continuity and differentiability of functions, properties. Intermediate value theorem (no proof). Uniform continuity, Differentiation in $\mathbb{R}^n$, Implicit and inverse function theorems (Statements and verifications, and applications only, no proof).


Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks. Eight questions of equal value will be set, of which any five are to be answered.

References

1. Fatema Chowdhury and Munibur Rahman Chowdhury, Essentials of Real Analysis.
2. W F Trench, Introduction to Real Analysis.

AMTH 202: Multivariate and Vector Calculus  4 credits

A. Differential Calculus


4. Extrema of functions of several variables, Lagrange multipliers. Taylor’s formula for functions of two variables.

B. Integral Calculus

3. Change of Variables in Multiple Integrals; Jacobians.
4. Topics in vector calculus: Vector Fields, Gradient, Divergence, curl and their physical meanings Line Integrals, Green’s Theorem, Surface Integrals, The Divergence Theorem, Stokes’ Theorem, Applications of Surface Integrals; Flux.

**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 4 hours) 70 Marks.
**Eight** questions of equal value will be set, of which any **five** are to be answered.

**References**
3. E. Swokowski, Calculus with Analytic Geometry.

**AMTH-203: Ordinary Differential Equations with Modeling**

4. Systems of Linear Differential Equations: Matrix form of a linear system, Homogenous and Non-homogeneous linear systems, Second order systems and Mechanical applications. Metapopulations, Natural killer cells and Immunity, Transport of Environmental pollutants, Solution by Diagonalization

**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
**Eight** questions of equal value will be set, of which any **five** are to be answered.

**References**
AMTH 204: Advanced Linear Algebra

1. Similar Matrices: Canonical forms of matrices, Similar matrices, Symmetric, orthogonal and Hermitian matrices.
2. Linear Functional and Dual Space: Linear functional and the dual space, Dual basis, Second dual space, Annihilators, Transpose of a linear transformation.
3. Inner Product Space: Inner products, Norms and inner product of vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$, Inner product spaces, Orthogonality and Gram-Schmidt process, orthonormal sets, Orthogonal complement, Linear functional and adjoints, Positive operators, Unitary operators and normal operators.
4. Bilinear, Quadratic and Hermitian Forms: Matrix form of transformations, Symmetric and skew symmetric bilinear forms, Canonical forms, Reduction form, Index and signature of real quadratic form, Definite and semi-definite forms, Hermitian forms, Principal minors and factorable forms.
5. Notions of Group: Definition and examples of groups and subgroups, symmetric and cyclic groups, normal subgroups and quotient groups, groups of small orders.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
2. W. Greub, Linear Algebra.

AMTH 205: Numerical Methods I

1. Preliminaries of Computing: Basic concepts, Floating point arithmetic, Types of errors and their computation, Convergence.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
AMTH 206: Discrete Mathematics  

1. Logic and Proofs: Propositional logic and equivalences, Rules of inferences and quantifiers, Methods of proof.
4. Graph theory and applications: Graphs and subgraphs, structure and symmetry of graphs, Graph isomorphism. Trees and connectivity, Eulerian and Hamiltonian graphs and diagraphs, Directed graphs, planar graphs.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
2. RP Grimaldi and BV Ramana, Discrete and Combinatorial Mathematics.

AMTH 207: Principles of Economics  

1. Basic Concepts: Definition and scope of economics, basic economic problems and their sources, choice, tradeoff and opportunity cost, economic systems - command economy, market economy and mixed economy; microeconomics and macroeconomics.
2. Demand and supply: definition, factors influencing them, demand and supply schedules & curves, law of downward-sloping demand, market demand and market supply, movements along and shifts in demand curve, shifts in supply curve, market equilibrium: price theory in the market, its implications, effects of a shift in demand or supply on equilibrium position, special cases.
3. Elasticity: Elasticity of demand and supply - concepts, definitions and problems associated with calculations, price elasticity, income elasticity and cross elasticity of demand, consumer’s expenditure pattern and total revenue in relation to elasticity of demand, computation of elasticity from demand function and family budget data.
5. The indifference Curve Analysis: Indifference curve analysis as an improvement over Marshallian analysis, consumer’s indifference curve: properties, rate of commodity substitution. The equilibriums position of tangency: consumer’s equilibrium, effects of income and price change on equilibrium.
Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
1. P.A. Samuelson, Economics.

AMTH 208: Principles of Statistics 3 credits

1. Concept of population, sample, parameter, statistic, random sample, sampling distribution, probability distribution, sampling distribution, standard error and their uses.
2. Some ideas about the distribution of sample mean, variance, correlation and regression coefficients, normal, F, t and $X^2$.
3. Preliminaries of tests: Hypothesis, simple and composite hypotheses, null and alternative hypotheses, concept of test of significance, procedures of a test, errors in testing of hypothesis, level of significance, one tailed and two-tailed tests, p-value. Tests based on usual normal, $X^2$, t and F statistics.
4. Testing the significance of a single mean, single variance, single proportion, difference of two means and proportions, ratio of two variances and their confidence intervals. Tests and confidence intervals concerning simple correlation coefficient and regression coefficient for single and double sample. Paired t-test. Testing the homogeneity of several population mean, variance and proportions. Statement about p-values for these tests.
5. Association of attributes, Association & disassociation, Measure of association, Attribute, contingency tables, General test of independence in an r x c contingency table. Fisher’s exact test for a 2x2 contingency table.
6. Test of goodness of fit. Analysis of Variance (ANOVA): One-way, two-way classification, etc.
7. Illustration with practical applications of simple mean, two means; several means; simple proportion, comparison of two proportions and several proportions.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
5. Steel &Torie, Principles and Procedures of Statistics.

AMTH 209: Mathematical Statistics 3 credits

1. Basic concept of random variable and its types, probability mass function, probability density function, distribution function, probability distribution and mathematical expectation.
3. Distribution of sum, difference, product and quotient of random variables, functions of random vectors of continuous and discrete type.
4. Central limit theorem, other limit laws and their applications.
5. Conditional expectations, Chebyshev’s inequality, probability generating function, characteristic function, inversion theorem.
6. Sampling distributions: Definition, examples from discrete and continuous populations, difference from probability distribution. Different methods of finding sampling distribution: Analytical method, inductive method, geometrical method, method of using characteristic function, etc. Sampling from the normal distributions, role of normal distribution in statistics, distribution of sample mean and variance and their independence for normal population.

7. Detailed study of Chi-square (χ²), Snedecor-Fisher’s F and Student’s t distribution, Sampling distribution of correlation and regression coefficients, frequency χ², and their uses.

8. Standard errors of statistics and their large sample approximations. Transformation of variables including square root, log, sin-inverse etc.


**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

**References**

2. Weatherburn, C.E., A First course in Mathematical Statistics.

**AMTH 250: MATH LAB II**

3 credits

Problem solving in concurrent courses (e.g., Calculus, Linear Algebra, Differential Equations, Numerical Analysis and Discrete Mathematics) using FORTRAN Programming.

Lab Assignments: There are at least 15 assignments.

**Evaluation:** Internal assessment (Laboratory works) 40 Marks.
Final examination (Lab, 3 hours) 60 Marks.

**AMTH 299: Viva Voce**

2 credits

Viva Voce on courses taught in the Second Year.
AMTH 301: Complex Variables and Fourier Analysis  

5. Conformal mappings: Elementary conformal mappings and their geometric properties. The bilinear transformations.
6. Beta and Gamma function: Introduction, different form of beta function, relationship between beta and gamma function, reduction of definite integrals to beta and gamma functions.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References

AMTH 302: Theory of Numbers  

2. The ring $\mathbb{Z}_n$ and its group of units. Chinese remainder theorem. Linear Diophantine equations.
5. Representation by sum of two and four squares.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
2. G.H. Hardy & E.M. Wright, An Introduction to Theory of Number.
3. I.S. Niven and H.S. Zuckermann, An Introduction to Theory of Number.
AMTH: 303  Partial Differential and Integral Equations  4 credits

1. Mathematical formulation and modeling of physical systems in PDE, well-posed problems, usual operators and classes of equations, boundary conditions, IVP, BVP, EVP, IBVP.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 4 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References

AMTH 304: Mathematical Methods  4 credits

1. Series solution of differential equations: Series solution about ordinary and singular point, regular and irregular singular point of a linear ODE, distinct roots not differing by an integer, repeated root of an indicial equation, distinct roots differing by an integer, Frobenius method for 2nd order ODE, Derivative method.
3. Green’s function and Fredholm alternative: Solution by eigenfunction expansion, Inverse of differential operator, Green’s function via Delta function, General linear boundary value problem, General Green’s Function, Applications to steady state heat equation and wave equations in 1D, steady state heat equation and potential flow problems (Laplace) in 2D and 3D, Fredholm alternative.
4. Special functions: Bessel functions (differential equations; series solutions; integral representations), Bessel functions of 1st and 2nd kind, applications; Legendre equations and
Legendre functions and their properties, generalization, applications; orthogonal polynomials: Legendre/Jacoby; Hermite; Laguerre, Chebyshev, Hypergeometric, confluent Hypergeometric and their applications.

5. Laplace transform and Inverse Laplace Transform: Definition, Laplace transform of some elementary functions; sufficient conditions for the existence of Laplace transform; some important properties of Laplace transform: translations, derivatives of a transform, transforms of integrals; initial and final value theorem; Laplace transforms of some special functions (periodic functions, Dirac Delta functions). Inverse Laplace, some important properties of the inverse Laplace transform; partial function decompositions; convolution theorem; Heaviside’s expansion formula; evaluation of integrals.

6. Applications of Laplace transform: Solving differential equations (ordinary and partial) using the Laplace transform, solving differential equations involving unit step functions and the Dirac Delta function, solving systems of ODEs using Laplace Transforms. Use of Laplace Transform techniques to model application problems from the physical sciences.

**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 4 hours) 70 Marks.

**Eight questions of equal value will be set, of which any five are to be answered.**

**References**
1. I. Stakgold, MJ Holst, Green's Functions and Boundary Value Problems.
3. N. N. Lebedev - Special functions and their applications.
5. KT Tang – Mathematical methods for Engineers and Scientists.

**AMTH 305: Numerical Methods II**

4. Initial value problems for ODE (Single-step methods) : Euler’s and modified Euler’s method, Higher order Taylor’s method, Runge-Kutta methods.
5. Extrapolation methods-higher order differential equations and systems of differential equations

**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

**Eight questions of equal value will be set, of which any five are to be answered.**

**References**
AMTH 306  Mechanics  3 credits

3.  Planetary motion: Equation of motion under a central force, Differential equation for the orbit, Orbits under an inverse square law.
4.  Vibrations: Free vibrations of particles, forced vibrations of particles, Rigid body vibrations
6.  Planar kinematics of Rigid Bodies: Plane angular motion, rotation about a fixed axis, relative motion of two points in a rigid body, motion relative to a rotating reference frame.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
1. Mary Lun, A first course in Mechanics.
4. David Acheson, From Calculus to Chaos An Introduction to Dynamics.

AMTH 307: Hydrodynamics  3 credits

2.  Hydrostatics, Liquid flow under conservative force, Bernoulli’s theorem, Applications of Bernoulli’s equation: Torricelli’s theorem, Sluice gate and its applications, Discharging a tank, etc.
4.  Potential flow, Stream function and Velocity potential in Cartesian and Polar-coordinates, Relation between stream function and velocity potential, Three-dimensional potential flows: Velocity potential, Stoke’s stream function.
5.  Joukowki’s transformation: Transformation of circle into straight line and ellipse, Method of images, Circle’s theorem, Flow past a circular cylinder with circulation and without circulation, Pressure distribution and Pressure coefficient on the surface of the Cylinder.
6.  Complex potential and complex velocity, Stagnation points, Uniform flows, Source, Sink, Vortex and Doublet. Complex potential due to source, sink, vortex and doublet.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.
References:

AMTH 308: Introduction to Financial Mathematics 3 credits

1. Overview of basic concepts in securities markets: Exchange-traded markets; Over-the-counter markets; Forward contracts; Future contracts; Options; Types of traders, etc.
2. Stochastic models for stock prices: Continuous-time stochastic processes; Wiener processes; The process for a stock price; The parameters; Ito's lemma; The lognormal property of stock prices.
3. Hedging strategies and managing market risk using derivatives: Financial derivatives; European call and put options; Payoff diagrams, short selling and profits; Trading strategies: Straddle, Bull Spread, etc; Bond and risk-free interest rate; No arbitrage principle; Put-call parity; Upper and lower bounds on call options.
4. Binomial option pricing model: One-step binomial model and a no-arbitrage argument; Risk-neutral valuation; Two-steps binomial trees; Binomial model for stock price; Option pricing on binomial tree; Matching volatility with $u$ and $d$; American put option pricing on binomial tree.
6. Black-Scholes analysis: Black-Scholes model; Black-Scholes Equation; Boundary conditions for call and put options; Exact solution to Black-Scholes equation; Delta-hedging; the Greek letters; Black-Scholes equation and replicating portfolio; Static and dynamic risk-free portfolio; Option on dividend-paying stock; American put option.
7. Interest rate models: Bond pricing with known interest rates and dividend payments; Zero-coupon bond pricing; Measure of future values of interest rate; Term structure of interest rate (Yield curve); Asian options: Derivation of PDE for option price.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References
1. J. Hull, Options, Futures and Other Derivatives.

AMTH 309: Optimization Techniques 4 credits

1. Introduction to linear programming: Basic definitions, Formulation of linear programming problems, Graphical solutions.
2. Simplex method and duality: Simplex method, Two phase method, Big-M simplex method, Duality of linear programming and related theorems (No Proof), Dual simplex method.
3. Sensitivity analysis: Analysis of the effect of changing various parameters in linear programming problems such as right hand side of the constraints, cost coefficients, addition of a new constraint, deletion of a constraint etc.
5. Transportation and assignment problem: Introduction, Formulation, Solution procedure, applications.
7. Decision theory and games: Introduction, Minimax-maximin pure strategies, Mixed strategies and Expected payoff, solution of 2X2 games, solution 2Xn and mX2 games, solution of m x n games by linear programming, Brown’s algorithm.

**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 4 hours) 70 Marks.
**Eight** questions of equal value will be set, of which any **five** are to be answered.

**References**

**AMTH 350: MATH LAB III**
3 credits

Problem solving in concurrent courses on First year to Third year using MATLAB Programming.
Lab Assignments: There are at least 15 assignments.

**Evaluation:** Internal assessment (Laboratory works) 40 Marks.
Final examination (Lab, 3 hours) 60 Marks.

**AMTH 399: Viva Voce**
2 credits

Viva Voce on courses taught in Third Year

**AMTH 401: Applied Analysis**
3 credits

**Part A: Topology**
1. Topological Spaces: Definition and examples (discrete, indiscrete, cofinite, cocountable topologies), closed and open set, interior, exterior and boundary points, derived set, cluster point of a set, dense set, relative topology, neighborhood system. Continuity.

**Part B: Functional Analysis**
7. Inner products, Inner product space and Hilbert Space, polarization identity, orthogonal and orthonormal sets in Hilbert space, Bessel’s inequality.
8. Fixed point theorems: Contraction mapping, Banach fixed point theorem, Applications of fixed point theorems.

**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
**Eight** questions of equal value will be set, of which any **five** are to be answered.

**References**
1. G.F. Simmons, Introduction to Topology and Modern Analysis.
2. S.Lipschutz, General Topology.

**AMTH 402: Fluid Dynamics**

3 credits

1. Fundamental concepts: Fluid as a continuum, Newton’s law of viscosity, Newtonian and non-Newtonian fluids, Body and surface forces, Stress and Rate of strain and their relation.
2. Navier-Stokes equations in different coordinate systems, Vorticity Transport Equation, Nondimensionalization, Dimensionless parameters, Reynolds similarity.
3. Unidirectional Flow, Exact solutions of the Navier-Stokes equations: Couette flows, plane Poiseuille flow, Flow through a circular pipe, the Hagen-Poiseuille flow, Flow between two coaxial cylinders and concentric circular cylinders, Pulsating flow between parallel surfaces, Stoke’s first and second problems.
5. Boundary layers: General concepts and properties of boundary layer. Prandtl’s boundary layer equations, boundary layer Separation, Similar and nonsimilar solutions of the boundary layer equations, Flow in a convergent channel, Flow past a wedge, Boundary layer on a flat plate, Boundary layer flow with pressure gradient, Karman’s integral equation, Karman-Pohlhausen method.
6. Thermal boundary layer: Energy equation, Thermal boundary layer simplifications, Natural and Forced flows, Parallel forced flow past a flat plate at zero incidence, Natural flow past a horizontal vertical plates.

**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
**Eight** questions of equal value will be set, of which any **five** are to be answered.

**References**
AMTH 403: Physical Meteorology  3 credits

2. Atmosphere: Origin of the atmosphere, Layering of the atmosphere; troposphere, stratosphere, mesosphere, thermosphere, exosphere and other layers of atmosphere, Composition of the atmosphere.
3. Thermodynamics of dry air: Pressure, temperature and ideal gas law; The Maxwell-Boltzmann distribution, hydrostatic equilibrium, surface pressure and mass of the atmosphere, surface pressure and sea level pressure, Heating, working and the First law; Enthalpy and the second law.
4. Thermodynamics of moist air: Six ways of quantify moister content, potential pressure, potential temperature, static stability of moister non-condensing air. The Claussius-Clapeyron equation, level of cloud formation.
5. Cloud and cloud formation: Cloud formation, cloud classification, various types of clouds, cloud droplet growth, droplet growth by diffusion and condensation, terminal velocity of falling drops.
7. Tropical Cyclone: Formation stage, Immature stage, mature stage, terminal stage; Climatological conditions for tropical cyclone formation, North Indian Ocean, Large scale conditions associated with tropical cyclone formation.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
2. Rodrigo Caballero, Lecture notes in Physical Meteorology.
4. Grant W. Petty, A first course in Atmospheric Radiation.

AMTH 404: Elementary Hydrology  3 credits

1. Definition and Introduction: Definition and scope of Hydrology, Hydrologic Cycle, Hydrologic System model, Hydrologic model classification, the development of Hydrologic Black Box model, Historical development, the Global water Budget.
2. Hydro-meteorology: Introduction, constituents of the atmosphere vertical structure of the atmosphere, solar radiation, the general circulation formulation of precipitation, types of precipitation, forms of precipitation. Climate and weather seasons in this subcontinents. Metrological observations.
3. Topography, watershed delineation, topographic effect (altitude, temperature) on precipitation.
4. Evaporation and transpiration, evapotranspiration.
5. Water in soils: infiltration and redistribution, vadose zone and soil moisture.
8. Hydrograph and Unit hydrograph methods and their applications.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

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References
2. V. Subramaniya, Engineering Hydrology.
3. Rafael L. Brus, Hydrology.
5. V.P. Sing, Elementary Hydrology.
6. S. Lawrence Dingman, Physical Hydrology.

AMTH 405: Differential Geometry and Tensor Analysis

Part A: Differential Geometry
1. Curves in Space: Vector functions of one variable and two variables, space curves, arc length, Tangent, Osculation plane, Normal, Principal normal, Binormal and fundamental planes. Curvature and torsion, Serret Frenet formula, Helics and their properties, Involute and Evolute.
2. Surface: Parametric curves, Tangent plane, normal and envelope, two and three parameter family of surfaces, First and second fundamental forms, Direction coefficients, orthogonal trajectories, Double family of curves. Curvature and directions, Rodrigue’s formula, Euler’s theorem.
3. Geodesics: Definitions, Differential equation of geodesics, geodesics on plane, sphere, right circular cone, cylinder, geodesic on a surface of revolutions.

Part B: Tensor Analysis
1. Vectors, Tensors and Co-ordinate transformations: Kronecker delta, Covariant and contravariant vectors, Mixed and invariant tensors, addition, subtraction and multiplication of tensors, contraction, symmetric and skew-symmetric tensors, Quotient Law.
3. Covariant Differentiations of Tensors: Covariant derivative of a tensor and higher rank tensors, intrinsic derivative, Tensor forms of gradient, divergence, curl and Laplacian, Riemann Christoffel tensor, Curvature tensor, Ricci tensor, Bianchi identity, Flat space and Einstein space and Applications.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 4 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
1. T.J. Willmore, An Introduction to Differential Geometry.
2. S. Stamike, Differential Geometry.
4. B. Spain, Tensor Calculus.

AMTH 406: Asymptotic Analysis and Perturbation Methods

1. Asymptotic equivalence, Asymptotic expansions. Taylor expansion as a conventional converging power series and as an example of an asymptotic expansion. Asymptotic expansions for definite integrals with the upper or lower limits of integration depending on small or large parameters. Functions defined by real integrals. Laplace's method for definite integrals, Watson's Lemma.
2. Generalisation for functions defined by contour integrals. Steepest descent. Applications. Asymptotic solutions of second-order linear equations (expansions near an irregular singularity, expansion for large arguments, equations containing a large parameter, equations involving a small parameter).


**Evaluation**: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

**References**

1. C. M. Bender and S.A. Orzag, Advanced Mathematical Methods for Scientists and Engineers.
2. J.D. Murry, Asymptotic Analysis.
3. F. W. J. Olver, Asymptotics and Special Functions.

**AMTH 407: Stochastic Calculus**

3 credits

2. The Ito's integral with respect to a Wiener process: Definition and basic properties. Continuous local martingales. The quadratic variation process. The Kunita-Watanabe inequality. Continuous semimartingales. The Ito's integral with respect to a continuous semimartingale: Definition and basic properties. Stochastic dominated convergence theorem.
4. The Ito-Clark theorem. The martingale representation theorem. Optimal prediction of the maximum process.

**Evaluation**: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

**References**

2. Revuz, D. and Yor, M., Continuous Martingales and Brownian Motion.

**AMTH 408: Econometrics**

3 credits

2. The Simple Regression Model: Definition of the Simple Regression Model, Deriving the Ordinary Least Squares Estimates, Properties of OLS on Any Sample of Data, Units of
Measurement and Functional Form, Expected Values and Variances of the OLS Estimators, Regression through the Origin.


4. Multiple Regression Analysis: Inference: Sampling Distributions of the OLS Estimators, Testing Hypotheses about a Single Population Parameter: The t Test, Confidence Intervals, Testing Hypotheses about a Single Linear Combination of the Parameters, Testing Multiple Linear Restrictions (The F Test), Reporting Regression Results.

5. Multiple Regression Analysis: OLS Asymptotics: Consistency, Deriving the Inconsistency in OLS, Asymptotic Normality and Large Sample Inference, Asymptotic Efficiency of OLS, Effects of Data Scaling on OLS Statistics (Beta Coefficients), More on Functional Form (Logarithmic Functional Forms, Models with Quadratics, Models with Interaction Terms).


Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References

AMTH 409: Actuarial Mathematics

2. Life Tables: Life tables, Actuarial Models, Deterministic survivorship group and random survivorship group, Continuous computations, Interpolating life tables, Select and Ultimate Tables.
3. Life insurance: Introduction to life insurance, Payments paid at the end of the year of death. Further properties of the APV for discrete insurance, Non-level payments paid at the end of the year, Payments at the end of the m-thly time interval, Level benefit insurance in the continuous case. Further properties of the APV for continuous insurance, Non-level payments paid at the end of the year, Computing APV's from a life table.
4. Life annuities: Whole life annuity, n-year deferred annuity, n-year temporary annuity, n-year certain annuity, Contingencies paid m times a year, Non-level payments annuities, Computing present values from a life table.
times a year. Non-level premiums and/or benefits. Computing benefit premiums from a life table, Premiums found including expenses.


**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

**References:**

**AMTH 410: Heat Transfer**

3 credits


**Evaluation:** Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

**References**
1. J. P. Holman, Heat Transfer.
AMTH 411: Modern Astronomy 3 credits

1. Celestial Sphere: Sphere and spherical triangles, the celestial sphere, problems connected with diurnal motion.
4. Geocentric parallax: The moon, Local line, Eclipses.
6. The Moon: Moon’s Librations, Relation between Sidereal months and synodic months, Phases of Moon, Moon’s Nodes and Nodal period, Daily retardation of moon-rise.

Evaluation: Incourse Assessment 30 Marks. Final examination (Theory, 3 hours) 70 Marks.
Eight questions will be set, of which any five are to be answered.

References
2. W.R. Smart, Spherical Astronomy.

AMTH 412: Quantum Theory and Special Relativity 3 credits

1. Wave-particle duality; Schrödinger's equation; stationary states; quantum states of a particle in a box, infinite square well potential, finite square wells, boundary conditions at a potential step, bound states in a finite well, reflection and transmission by a finite step, and by a barrier, tunnelling.
2. The one-dimensional harmonic oscillator; higher-dimensional oscillators and normal modes; degeneracy.
3. The basic postulates of quantum mechanics; Commutation relations and compatibility of different observables; Heisenberg's uncertainty principle.
4. Angular momentum in quantum mechanics, angular momentum operators; Orbital angular momentum, particle in two dimensions (eigenfunctions and eigenvalues of L_z), particle in three dimensions (eigenfunctions and eigenvalues of \( L^2 \) and \( L_z \)), rotational states of a diatomic molecule; Spherical harmonics
7. Constancy of the speed of light, Galilean relativity, Maxwell’s equations, wave equation in electromagnetism, Principles of Einstein’s special relativity, Lorentz transformations, time dilation, length contraction, simultaneity, space-time separation, the Twin paradox, causality.
8. Tensor equations, Index notation, four-vectors, four-velocity and four-momentum; equivalence of mass and energy: \( E = mc^2 \); particle collisions and four-momentum conservation; Photons and Compton scattering, mass transport by photons, particle production and decay, four-acceleration and four-force, Lorentz force, the example of the constant-acceleration world-line, the relativistic Doppler effect.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.
References
2. P.C.W. Davies and D.S. Betts, Quantum Mechanics.
4. A.I.M. Rae, Quantum Mechanics.
5. N. M. J. Woodhouse, Special Relativity.

AMTH 413: Mathematical Modelling in Biology and Physiology 3 credits
1. Introduction to Modelling in Biology.
5. Introduction to Physiology.
8. Cellular homeostasis.
9. Membrane ion channels.
10. The Hodgkin-Huxley model.
11. Excitability.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

References
3. James Keener and James Sneyd, Mathematical Physiology.

AMTH 414: Mathematical Neuroscience 3 credits
1. Introduction to Neurons,
2. Neural encoding and decoding
3. The Hodgkin–Huxley Equations
4. Dynamical Systems and Neuronal Dynamics
5. The Variety of Channels
6. Bursting Oscillations
7. Propagating Action Potentials
8. Synaptic plasticity
9. Neural Oscillators
10. Neuronal Networks: Fast/Slow Analysis
11. Firing Rate Models

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.
References
2. Alla Borisyuk, Avner Friedman, Bard Ermentrout, David Terman - Tutorials in Mathematical Biosciences I.

AMTH 415: Industrial Mathematics 3 credits
2. Data acquisition and manipulation: The z-transform, Linear recursions, Filters, Stability, Polar and Bode plots, Aliasing, Closing the loop, Why decibels?
5. Microeconomics: Supply and demand, Revenue, cost, and profit, Elasticity of demand, Duopolistic competition, Theory of production, Leontiev input/output

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

Reference

AMTH 416: Computational Science and Engineering 3 credits
1. Applied Linear Algebra: Four Special Matrices, Differences, Derivatives, and Boundary Conditions, Elimination Leads to $K = LDL^T$, Inverses and Delta Functions, Positive Definite Matrices, Numerical Linear Algebra: LU, QR, SVD.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.
References

AMTH 430: Special Topics 3 credits
Any mathematical topic not covered in other courses may be offered under this title. The course-teacher will prepare an outline of the course and obtain the approval of the departmental academic committee.

Evaluation: Incourse Assessment 30 Marks, Final examination (Theory, 3 hours) 70 Marks.
Eight questions of equal value will be set, of which any five are to be answered.

AMTH 450: MATH LAB IV (Application softwares) 3 credits

AMTH 460: Honours Project 3 credits
Each student is required to work on a project and present a project report for evaluation. Such projects should be extensions or applications of materials included in different honours courses and may involve field work and use of technology. There may be group projects as well as individual projects.
The Academic Committee shall form a Project Coordination and Evaluation Committee (PCEC) at the beginning of the session. The PCEC shall consist of a project Coordinator (PC) and members as the Academic Committee considers appropriate. The PC shall invite projects from the teachers before the class start. Each teacher should submit three project proposal should include a short description of the project. Such projects should be extension or applications of materials included in different courses, and may involve fieldwork and use of technology.
The PCEC shall assign each group a project. The members of each group shall work independently on the assigned project under the supervision of the concerned teacher. The PCEC and the supervisors will monitor the progress of different projects.

Completion of project:
The project must be completed before the termination of the classes. Each student is required to prepare a separate report on the project. Each report should be of around 40 pages typed on one side of A4 size white paper preferably using word processors. Graphs and figures should be clearly drawn preferably using computers. Reports of different students working on the same group project should differ in some details and illustrations.
The Academic Committee will select a date for the submission of the project reports to the PCEC. Each student must submit three printed copies of her/his project report to the PCEC on or before the date announced for such submission.
The PCEC, on receiving the reports will arrange the presentation of reports by individual students before the PCEC. This presentation should take place soon after the completion of the written examination.
Any student who fails to submit the report on the due date or to present the thesis on the fixed date will not get any credit for this course.

AMTH 499: Viva Voce 2 credits
Viva Voce on courses taught in Fourth Year.