Students of M.Phil/Ph.D. programme will be offered four/five courses in the first semester and four/five courses in the second semester.

**Note:** The students of Ph.D. programme after qualifying the CGPA>3.0 in the first year of their course work will be offered additional courses to complete their 48 credit hours studies during the second/third year of Ph.D. programme.

### a. Core Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCO-501</td>
<td>Riemannian Geometry</td>
<td>3 credits</td>
</tr>
<tr>
<td>MCO-502</td>
<td>Mathematical Techniques</td>
<td>3 credits</td>
</tr>
<tr>
<td>MCO-503</td>
<td>ODEs and Computational Linear Algebra</td>
<td>3 credits</td>
</tr>
<tr>
<td>MCO-504</td>
<td>Partial Differential Equations</td>
<td>3 credits</td>
</tr>
<tr>
<td>MCO-505</td>
<td>Integral Equations</td>
<td>3 credits</td>
</tr>
<tr>
<td>MCO-506</td>
<td>Group Theory</td>
<td>3 credits</td>
</tr>
<tr>
<td>MCO-507</td>
<td>Functional Analysis</td>
<td>3 credits</td>
</tr>
<tr>
<td>MCO-508</td>
<td>Advanced Mathematical Physics</td>
<td>3 credits</td>
</tr>
</tbody>
</table>

### Optional Courses

#### b. Applied Mathematics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA-601</td>
<td>General Relativity-I</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-602</td>
<td>General Relativity-II</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-603</td>
<td>Cosmology</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-604</td>
<td>Relativistic Astrophysics</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-605</td>
<td>Classical Field Theory</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-606</td>
<td>Electrodynamics-I</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-607</td>
<td>Electrodynamics-II</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-608</td>
<td>Magnetohydrodynamics-I</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-609</td>
<td>Magnetohydrodynamics-II</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-610</td>
<td>Fluid Dynamics</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-611</td>
<td>Elastodynamics</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-612</td>
<td>Plasma Physics</td>
<td>3 credits</td>
</tr>
<tr>
<td>MA-613</td>
<td>Advanced Course in Plasma Physics</td>
<td>3 credits</td>
</tr>
</tbody>
</table>
c. **Computational Mathematics**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-621</td>
<td>Theory of Spline Functions I</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-622</td>
<td>Theory of Spline Functions II</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-623</td>
<td>Theory of Spline Functions III</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-624</td>
<td>Subdivision Schemes</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-625</td>
<td>Approximation Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-626</td>
<td>Numerical Solution of PDEs</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-627</td>
<td>Graph Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-628</td>
<td>Design Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-629</td>
<td>Mathematical Modeling-I</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-630</td>
<td>Mathematical Modeling-II</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-631</td>
<td>Minimal Surfaces</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MC-632</td>
<td>Computer Graphics</td>
<td>(3 credits)</td>
</tr>
</tbody>
</table>

d. **Pure Mathematics**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP-641</td>
<td>Rings and Modules</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-642</td>
<td>Operator Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-643</td>
<td>Lie Algebras &amp; Lie Groups</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-644</td>
<td>Field Extensions &amp; Galois Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-645</td>
<td>Linear Groups &amp; Group Representations</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-646</td>
<td>General Topology</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-647</td>
<td>Homotopy Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-648</td>
<td>Topological Groups</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-649</td>
<td>Homological Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-650</td>
<td>Lattice Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-651</td>
<td>Representation Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-652</td>
<td>BCK Algebra</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-653</td>
<td>BCI Algebra</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-654</td>
<td>Advanced Theory of Rings and Modules</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-655</td>
<td>Spectral Theory in Hilbert spaces – I</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-656</td>
<td>Spectral Theory in Hilbert spaces – II</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-657</td>
<td>Harmonic Analysis</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-658</td>
<td>Banach Algebras-I</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-659</td>
<td>Banach Algebras-II</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-660</td>
<td>Advanced Measure Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-661</td>
<td>Advanced Number Theory</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>MP-662</td>
<td>Combinatorics</td>
<td>(3 credits)</td>
</tr>
</tbody>
</table>

e. **Reading and Research**
MRR-671  Reading & Research-MA1          (3 credits)
MRR-672  Reading & Research-MA2          (3 credits)
MRR-673  Reading & Research-MC1          (3 credits)
MRR-674  Reading & Research-MC2          (3 credits)
MRR-675  Reading & Research-MP1          (3 credits)
MRR-676  Reading & Research-MP2          (3 credits)

f. Non-Credit Courses

MSA-681  Seminar Attendance          (0 credits)
MSA-682  Seminar Delivered-G          (0 credits)
MSA-683  Seminar Delivered-T          (0 credits)
MSA-684  Seminar Delivered-R          (0 credits)

g. M.Phil. Thesis

MTH-690  Thesis                        (6 credits)

h. Ph.D. Thesis

MTH-699  Thesis                        (48 credits)
COURSE OUTLINES

CORE COURSES:

MCO-501 RIEMANNIAN GEOMETRY


Recommended Books


MCO-502 MATHEMATICAL TECHNIQUES


Recommended Books:


**MCO-503 ODEs AND COMPUTATIONAL LINEAR ALGEBRA**


**Recommended Books**


**MCO-504 PARTIAL DIFFERENTIAL EQUATIONS**


**Recommended Books**


**MCO-505 INTEGRAL EQUATIONS**


**Recommended Books**


**MCO-506 GROUP THEORY**


**Recommended Books**

MCO-507 FUNCTIONAL ANALYSIS


Recommended Books


MCO-508 ADVANCED MATHEMATICAL PHYSICS


Recommended Books

OPTIONAL COURSES:

APPLIED MATHEMATICS

MA-601 GENERAL RELATIVITY-I


Recommended Books

MA-602 GENERAL RELATIVITY-II (Pre-requisite of MA-601)


Recommended Books

**MA-603   COSMOLOGY**


**Recommended Books**


**MA-604   RELATIVISTIC ASTROPHYSICS**


**Recommended Books**


**MA-605    THE CLASSICAL THEORY OF FIELDS**


**Recommended Books**


**MA-606    ELECTRODYNAMICS-I**


**Recommended Books**


**MA-607 ELECTRODYNAMICS-II (Pre-requisite of MA-606)**


**Recommended Books**


**MA-608 MAGNETOHYDRODYNAMICS-I**


**Motion of an Incompressible Fluid:** Motion of a viscous electrically conducting fluid with linear current flow. Steady state motion along a magnetic field. Wave motion of an ideal fluid.

**Small Amplitude MHD Waves:** Magneto-sonic waves. Alfven’s waves. Damping and excitation of MHD waves. Characteristics lines and surfaces.


**Recommended Books**

MA-609    MAGNETOHYDRODYNAMICS-II (Pre requisite of MA-608)


Recommended Books


MA-610    FLUID DYNAMICS


Recommended Books

MA-611  ELASTODYNAMICS


Recommended Books


MA-612  PLASMA PHYSICS

Introduction to plasma physics, occurrence of plasmas in nature, concept of temperature, Debye shielding, criteria for plasmas, applications of plasma physics. Single particle motion, motion of charged particles in uniform E and B fields, adiabatic invariants. Plasmas as fluids, relation of plasma physics to ordinary electromagnetic, the fluid equation of motion, equation of continuity, the complete set of fluid equations, plasma approximations. Waves in plasmas, representation of waves, group velocity, plasma oscillations, electron plasma waves, sound waves, ion waves, validity of plasma approximation, comparison of ion wave and electron wave, electrostatic electron oscillations perpendicular to B, electrostatic ion waves perpendicular to B, the lower hybrid frequency, EM waves with Bo=0, EM waves perpendicular to Bo, cutoffs and resonances, EM waves parallel to Bo, hydromagnetic waves, magnetosonic waves.

Books Recommended

MA-613 ADVANCED COURSE IN PLASMA PHYSICS

Diffusion and mobility in weakly ionized gases, decay of plasma by diffusion, steady state solutions, recombination, diffusion across a magnetic field, collisions in fully ionized plasmas, the single-fluid MHD equations, diffusion in fully ionized plasmas, solutions of the diffusion equation, Bohm diffusion and neoclassical diffusion. Equilibrium and stability – introduction, hydromagnetic equilibrium, the concept of B. diffusion of magnetic field into a plasma, classification of instabilities, two-stream instability, the “Gravitational” instability, resistive drift waves, the Weibel instability. Kinetic theory, the meaning of \( f(v) \), equations of kinetic theory, derivations of fluid equations, plasma oscillations and Landau damping, a physical derivation of Landau damping, ion Landau damping, kinetic effects in a magnetic field. Nonlinear effects – introduction, sheaths, ion acoustic shock waves, the pondermotive force, parametric instabilities, plasmas echoes, nonlinear landau damping, equations of nonlinear plasma physics.

Books Recommended


MA-614 QUANTUM FIELD THEORY

Classical field theory, lagrangian mechanics, variational principle, vibrating stings, classical field theory, Lorentz transformations, Lorentz group, representations of Lorentz group, classical scalar fields, Klein-Gordon equation, complex scalar fields, energy-momentum tensor, electromagnetic field, Maxwell’s equations, spinor field, Dirac equation, symmetries and conservation laws, Noether’s theorem, translation invariance. Quantization of fields, canonical quantization of fields, quantization of scalar fields, particle interpretation of quantum field theory, normal ordering, non-Hermitian fields. Interacting Quantum Fields, interacting fields, perturbation theory, time ordering, S-matrix, cross section, decay rate of an unstable particle, higher order perturbation theory, Wick’s theorem second order perturbation theory, Feynman rules and diagrams, renormalization, mass renormalization, coupling constant renormalization, field renormalization.
Books Recommended

COMPUTATIONAL MATHEMATICS

MC-621 THEORY OF SPLINE FUNCTIONS I


Recommended Books


MC-622 THEORY OF SPLINE FUNCTION II (Pre-requisite MC-614)

Interpolatory cubic splines. The representation of s in terms of the values M_i=s^{(2)}(x_i), i=0,1,2,...,k. The representation of s in terms of the values m_i=s^{(1)}(x_i), i=0,1,2,...,k. Quadratic Hermite spline. Theorems regarding error analysis. Theorems regarding to Convergence of the D1, D2, natural and periodic splines. End conditions for cubic Hermite spline interpolation. E(α)-cubic splines.

Recommended Books


**MC-623 THEORY OF SPLINE FUNCTIONS III (Pre-requisite MC-615)**

End conditions for interpolatory spline with unequally spaced knots. Superconvergence (Equally-spaced knots). Cubic spline collocation for two point boundary value problems. B-spline representation in terms of divided differences. The B-spline representation of spline functions. Computational considerations: The representation of B-splines (Method based on the recursive definition of divided differences). Method of additional knots. The computation of $s(x)$. The computation of derivatives.

**Recommended Books**


**MC-624 SUBDIVISION SCHEMES**


Recommended Books


MC-625 NUMERICAL SOLUTIONS OF PDEs


Recommended Books


MC-626 APPROXIMATION THEORY


Recommended Books


**MC-627 GRAPH THEORY**


**Recommended Books**


**MC-628 DESIGN THEORY**


**Recommended Books**

MC-629    MATHEMATICAL MODELLING-I


Recommended Books


MC-630    MATHEMATICAL MODELLING-II (Pre-requisite of MC-622)


Recommended Books


MC-631    MINIMAL SURFACES

Regular surfaces: Differentiable functions on surfaces. The tangent plane. Geometric definition of area. Gaussian and mean curvature. Curvature in local coordinates. Ruled and minimal surfaces: Historical survey and introduction to the theory of minimal surfaces. Basic minimal surface properties. Topological and physical properties. Stable

**Recommended Books**


**MC-632 COMPUTER GRAPHICS**

Introduction to computer graphics and its applications. Overview of raster graphics and transformation pipeline, i.e. transformations between different coordinate systems which involve modelling coordinate system. Device coordinate system. World coordinate system. Normalized coordinate system. Display window coordinate system and screen coordinate system. Graphics output primitives in drawing of lines, polygons, triangles, etc. Draw polylines with different line joining methods. Attributes of graphics primitives like colour, line style and fill style. 2D and 3D transformations and viewing. Describing and using viewing parameters to change the shape of the object, using viewport to change the ratio of clipping window. Differences in viewing and modelling transformations. Window clipping by Cohen-Sutherland algorithm.

**Recommended Books**

PURE MATHEMATICS

MP-641 RINGS AND MODULES


Recommended Books


MP-642 OPERATOR THEORY


Compact linear Operators on Normed Spaces and their Spectrum: Compact linear operators on normed spaces. Further properties of compact linear operators. Special properties of compact linear operators on normed spaces.


Recommended Books


**MP-643 LIE ALGEBRAS & LIE GROUPS**


**Recommended Books**


**MP-644 FIELD EXTENSIONS AND GALOIS THEORY**


**Recommended Books**


**MP-645 LINEAR GROUPS AND GROUP REPRESENTATIONS**

Recommended Books


MP-646   GENERAL TOPOLOGY


Recommended Books


MP-647   HOMOTOPY THEORY


Recommended Books


10/7/2010 24 08:57:49
MP-648        TOPOLOGICAL GROUPS


Recommended Books


MP-649        HOMOLOGICAL THEORY


Recommended Books


MP-650        LATTICE THEORY

**Distributive lattices:** Distributive lattices, Characterization and representation theorems. Polynomials and freeness. Congruence relations. Boolean algebra.

**Recommended Books**


**MP-651 REPRESENTATION THEORY**


**Recommended Books**


**MP-652 BCK ALGEBRA**

Recommended Books


**MP-653**  BCI ALGEBRA

**Classification of BCI Algebras:** Implicative, Positive implicative BCI algebras. S1, S2, S3 and S4 algebras.

**Classification of ideals in BCI Algebras:** Ideals in BCI algebra, Strong and weak ideals. Obstinate ideals. Ideals in P-semi simple algebras. Regular and non regular ideals. Quotient algebras. Quotient BCI algebras and BCI homomorphism.

Recommended Books


**MP-654**  ADVANCED THEORY OF RINGS AND MODULES


Recommended Books


MP-655  SPECTRAL THEORY IN HILBERT SPACES – I
(Pre-requisite: Linear Algebra, Real and Complex analysis.)


Recommended Books


MP-656  SPECTRAL THEORY IN HILBERT SPACES – II
(Pre-requisite of MP-639)


**Recommended Books**


**MP-657 HARMONIC ANALYSIS**

(Pre-requisite: Linear Algebra, Real and Complex analysis, Topology)


**Recommended Books**


**MP-658 BANACH ALGEBRAS - I**
(Pre-requisite: Algebra, Real and Complex analysis, Topology)


**Symmetric Rings:** Definition and simplest properties of a symmetric ring. Positive functionals. Normed symmetric rings. Positive functionals in a symmetric Banach ring.

**Books Recommended**

**MP-659 BANACH ALGEBRAS – II (Pre-requisite of MP-642)**

**Commutative Normed Rings:** Factor-ring modulo a maximal ideal. Functions on maximal ideals, generated by elements of a ring. Topologization of the set of all maximal ideals. The case of a ring without identity. System of generators of a ring. Analytic functions of ring elements. Analytic functions of several ring elements. Decomposition of
a ring into the direct sum of ideals. Primary ideals. Homomorphism and isomorphism of
commutative rings. Uniqueness of the norm in a semi simple ring. The case of symmetric
rings.

**Ring boundary:** Definition and fundamental properties of the ring boundary. Extension
of maximal ideals. Completely symmetric commutative rings. Definition of a completely
symmetric ring. Criterion for complete symmetry. Application of Stone’s theorem. The
ring boundary of a completely symmetric ring.

**Regular Rings:** Definition of a regular ring. Normal ring of functions. Lattice space of a
ring. Properties of regular rings. The case of a ring without identity. Sufficient condition
that a ring be regular.

**Completely regular Commutative rings:** Definition and simplest properties of a
completely regular ring. Realization of completely regular commutative rings. Generalization to pseudo-normed rings.

**Recommended Books**

2. Loomis, L. H.: *An Introduction to Abstract Harmonic Analysis* (Van Nostrand,
   1953).
3. Wojtaszczyk, P.: *Banach Sspaces for Aanalysts* (Cambridge University Press,
6. Helemskii, A. Y.: *A Banach and Locally Convex Algebras* (Oxford University
   Press, 1993).

**MP-660 ADVANCED MEASURE THEORY**

(Pre-requisite: Set Theory, Real analysis.)

Riemann-Stieltjes and Lebesgue integration. Classical Banach Spaces. Weierstrass’
convergence theorem. Singed measures. The Radon-Nikodym theorem. Product
measures. Inner measure. Extension by sets of measure zero. Caratheodory outer
measure. Hausdorff measure

**Recommended Books**


**MP-661 COMBINATORICS**


**Recommended Books**


**PM-662 ADVANCED NUMBER THEORY**


**Recommended Books**


**MSA-681 Seminar Attendance**
All students must attend the weekly Colloquium at Department of Mathematics. At least 80% attendance is necessary for a PhD student.

**MSA-682 Seminar Delivered-G**
A seminar delivered by a PhD student outside the thrust area chosen.

**MSA-683 Seminar Delivered-T**
A seminar delivered by a PhD student in the thrust area chosen but not from the student’s PhD research area.

**MSA-684 Seminar Delivered-R**
A seminar delivered by a PhD student in the student’s PhD research area.