DEPARTMENT OF MATHEMATICS  
UNIVERSITY OF THE PUNJAB  

COURSES OF M.PHIL/M.PHIL LEADING PH.D./ PH.D.  
(2010-ONWARD)

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

MCO-501 Riemannian Geometry (3 credits)
MCO-502 Mathematical Techniques (3 credits)
MCO-503 ODEs and Computational Linear Algebra (3 credits)
MCO-504 Partial Differential Equations (3 credits)
MCO-505 Integral Equations (3 credits)
MCO-506 Group Theory (3 credits)
MCO-507 Functional Analysis (3 credits)
MCO-508 Advanced Mathematical Physics (3 credits)

b. Applied Mathematics

MA-601 General Relativity-I (3 credits)
MA-602 General Relativity-II (3 credits)
MA-603 Cosmology (3 credits)
MA-604 Relativistic Astrophysics (3 credits)
MA-605 Classical Field Theory (3 credits)
MA-606 Electrodynamics-I (3 credits)
MA-607 Electrodynamics-II (3 credits)
MA-608 Magnetohydrodynamics-I (3 credits)
MA-609 Magnetohydrodynamics-II (3 credits)
MA-610 Fluid Dynamics (3 credits)
MA-611 Elastodynamics (3 credits)
MA-612 Plasma Physics (3 credits)
MA-613 Advanced Course in Plasma Physics (3 credits)
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MA-614</td>
<td>Quantum Field Theory</td>
<td>(3 credits)</td>
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</table>

### c. Computational Mathematics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<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>
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<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>
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<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>
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### d. Pure Mathematics

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<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>
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<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>
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<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>
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</tbody>
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### e. Reading and Research

10/7/2010 08:57:49
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 ADVANCED NUMERICAL ANALYSIS**


**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)**

**Flow of Conducting Fluid Past Magnetized Bodies:** Flow of an ideal fluid past magnetized bodies. Fluid of finite electrical conductivity flow past a magnetized body.


**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 filed 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 FUNCTIONS 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($\alpha$)-cubic splines.

**Recommended Books**

2006).

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


**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


Recommended Books


Recommended Books


Recommended Books


**MP-646 GENERAL TOPOLOGY**

**Topological spaces:** Product spaces. Weak topologies and quotient spaces.


Recommended Books


**MP-647 HOMOTOPY THEORY**


Recommended Books

MP-648  TOPOLOGICAL GROUPS

Fundamentals of topology and groups. General theory of topological groups. Topological algebraic structures. Topological groups. Separation axioms in topological groups subgroups and quotient groups. Metrizable complete topological groups. Locally compact groups. General results on locally compact groups. Liner groups. Locally Euclidean groups. Lie groups. Continuous and open homeomorphisms in 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. $S_1$, $S_2$, $S_3$ and $S_4$ 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’
Differentiation under the integral sign. Classical Banach Spaces. \(L^p\)–spaces. Convergence
and completeness in \(L^n\)–spaces. Bounded linear functional on the \(L^n\)–spaces. General
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.