Pre-Ph.D. Course Mathematics

1) Research Methodology (Mathematics) (5 credits) (Compulsory)

1. LaTeX and Beamer (10 hours)
2. At least one Mathematical software out of the following: Scilab /KASH/ Maxima/ SAGE/ Other software suggested by the research guide (10hours)
3. Working knowledge of MathSciNet, JSTORE and other online journals, Review of a research paper (4 hours)
4. Rapid Reader: Mathematics and its History, by J. Stillwell, Springer International Edition, 4th Indian Reprint, 2005. (10 hours)
5. Participating in seminar/lecture son different topics in Mathematics (6 hoarse)

2) ATM School Participation (5 credits) (Optional)

Advanced Training in Mathematics (ATM) school have been devised by National Board for Higher Mathematics to broaden the knowledge of a research student in Mathematics and also inculcating problem solving skills for better understanding of the subject and developing research orientation. A student participating in an NBHM sponsored ATM school of 3-4 weeks duration such as Annual Foundation School I for II or an Advanced Instructional School on a specific topic will earn 5 credits provided the school is attended after getting provisional admission for Ph.D. The Research Guide will request the coordinator of the school to give a grade to the student based on the participation of the student in the ATM school.

3) Differential Equations (5 credits) (Optional)

(A) Revision:

1. Linear system of ordinary differential equation, symptotic stability, existence uniqueness theorems.
2. Elementary Practical Differential Equations. Laplace, Heat and wave equations. Separation of variable method.

(B) Classification and Characteristics of Higher Order PDFs: Cauchy-Kovalevskaya Theorem. Holmgren's Uniqueness Theorem.

(C) Conservation Laws and Shocks systems in one dimension : conservation laws, weak solution, Lax Shock Solution, Riemann Problems, Dirichlet Problem. Maximum Principles for parabolic equations; (i) weak maximum principle, (ii) strong maximum principle.

Reference Books:

1. An Introduction to Partial Differential Equations, M. Renardy & R. C. Rogers (Springer), (Second Edition).
2. Differential Equations, Dynamical Systems and an Introduction to Chaos, 2nd Edn., by MW. Hirsch, S. Smale, R. L. Devaney, Elsevier, 2004

4) Fourier Series and Functional Analysis (5 Credits) (Optional)

Conditional, unconditional and absolute convergence of a series in a normed linear space; notion of an orthonormal basis for a Hilbert space Trigonometric series, Fourier series, Fourier sine and consine series Piecewise continuous/smooth functions, absolutely continuous functions, functions of bounded variation (and their significance in the theory of Fourier series) Generalized Riemann-Lebesgue lemma Dirichlet and Fourier kernels Convergence of Fourier series Discussion (Without proofs) of some of the following topics: The Gibbs phenomenon, divergent Fourier series, term-by-term operations on Fourier series, various kinks of summability, Fejer theory, multivariable Fourier series.

Reference:

1. Georage Bachman, Lawrence Narici and Edward Beakenstein, Fourier and Wavelet Analysis, Springer-Verlag, New York, 2000
2. Richard L. Wheeden and Antoni Zygmund, Measure and integral, Marcel Dekker Inc., New York, 1977.
3. Balmohan V. Limaye, Functional Analysis, New Age International (P) Ltd. New Delhi, 2004.

5) Complex Analysis (5 Credits) (Optional)

(1) Analytic functions, Path integrals, Winding number, Cauchy integral formula and consequences. Gap theorem, Isolated singularities, Residue theorem, Liouville theorem.

(2) Casorati- Weierstrass therorem, Bloch-Landau therorem, Picard's therorems, Mobius transformations, Schwartz lemma, External metrics, Riemann mapping theorem, Argument principle, Rouche's therorem..

(3) Runge's theorem, Infinite products, Weierstrass p-function, Mittag-Leffler expansion.

References:

1. Murali Rap & H. Stetkaer, Complex Analysis, World Scinetific, 1991.
2. L. V. Ahlfors, Complex Analysis, McGraw-Hill, Inc., 1996.
3. A. R. Shastri, Complex Analysis, 2010.
4. S. G. Krantz, Complex Analysis: The Geometric View Points, Second edition, Carus Math. Monographs, MAA.

6) Commutative Algebra (5 Credits) (Optional)

Prime ideals and maximal ideals, Zariski topology, Nil and Jacobson, radicals, Localization of rings and modules, Noetherian rings, Hilbert Basis theorem, modules, primary decomposition, integral dependence, Noether normalization lemma, Krull's principal ideal

theorem, Hilbert's Null-stellensatz, Structure of artinian rings, Dedekind domains. Introduction to Algebraic Number Theory. Discriminants of number field.
Factroisation of ideals. Finiteness of class number. Euclidean number rings.

Text-book:

1. Paul Ribenboim, Algebraic Number Theory.

Additional References:

2. M. F. Atiyah and I. G. Macdonald, Introduction to commutative algebra.
3. P. Samuel, Algebraic Number Theory.

1) Algebraic Graph Theory (5 Credits) (Optional)

0. Introduction: Graph theory, Linear algebra. Group theory.
1. Eigenvalues of graphs: Some examples. Eignvalus and walks, Eigenvalues and labllings of graphs, Lower bounds for the eigenvalues, Upper bounds for the Eigenvalues, Other matrices related to graphs, Cospectral graphs.
2. Spectral graph theory, Star sets and star partitions, Star completes, Exceptional graphs, Reconstructing the characteristic polynomial, Non-complete extended p-sums of graphs, Integral graphs
3. Graph Laplacians. The Laplacian of a graph, Laplace eigenvalues, Eigenvalues and vertex partitions of graph, The max-cut problem and semi-definite programming, Isoperimetric inequalities, The traveling salesman problem, Random walks on graphs.
4. Auromorphisms of graphs: Graph auromorphisms, Algorithmic aspects, Automorphisms of typical graphs, permutation groups, Abstract groups, Cayley graphs, Vertex-transitive graphs.
5. Distance-transitive graphs: Distance-transitivity, Graphs from groups, Combinatorial properties, imprimitivity, Bounds, Finite simple groups, The first step, The affine case, The simple scole case.
6. Computing with graphs and groups: Permutation group algorithms, Strong and accessing a G-graph, Constructing G-graphs, graph, G-breadth-first search in a G-graph, Automorphism groups and graph is isomorphism, Computing with vertex-transitive graphs, Coset enumeration, Coset enumeration for symmetric graphs.

Book : Topics in Algebraic Graph Theory.
Authors : L. W. Beinke and R. J. Wilson
Publisher : Cambridge University Press

8) Course suggested by the Research Guide (5 Credits) (Optional)

There will be a course conducted by the research guide of the Ph.D. student. As per the recommendation of the guide, the student may take a reading course
With the guide or one of the optional courses in liu of it.

9) **If found necessary, course work may be carried out by doctoral**

Candidates in sister Departments/Institutes either within or outside the University for Which
due credit will be given to them. The student.
Can opt for such a course upon recommendation of the Guide and the Chairman, Ph.D. committee/HOD. Such course-work done outside the department should be restricted to 10 credit points.

The total number of credits the student should get in the pre-Ph.D. courses is 20.
The credits are distributed as follows:

1. Research Mehodology:5 credits
2. Core Mathematics:10 credits
   The students should take 2 optional courses of 5 credits each to get 10 credits.
3. Reading course with the Research Guide (or an optional course in lie of it): 5 credits.

Note: The above mentioned courses with the given syllabi can also be considered as M. Phil. courses.