SCHEME OF EXAMINATION AND COURSE OF STUDY

SYLLABUS

FACULTY OF SCIENCE

COURSE WORK FOR M. Phil./ Ph.D.
STUDENTS IN MATHEMATICS

EXAMINATION 2020 AND ONWARDS

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur
Course work for Ph.D. students in Mathematics – 2020 and onwards

Scheme of Examination: Semester-I

For Semester – I teaching is common for both Ph.D. and M.Phil. students. (Papers, Syllabus and Scheme of Examination are also common)

There shall be four papers in all. Two papers are compulsory and two papers are elective.

| Each Theory paper and dissertation | Max. Marks – 80 |
| Internal assessment                | Max. Marks – 20 |
|                                   | Total Marks – 100 |

(for each four papers)

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Semester – I is common for both Ph.D. and M.Phil. students.

Teaching Pattern:

Self study with guidance from a Faculty Member, who will act as Supervisor. To start with, each Supervisor will give one seminar lecture to all the students offering the paper so as to provide a model to the students.

For Semester – I,

The papers are as follows:

Paper – I: Research Methodology
Paper – II: Analysis of Published Research Paper
(A short dissertation is to be submitted by each student under the supervision of a faculty member)

Each student has to opt two papers out of the following

Papers III to IX:

Paper – III: Advanced Numerical Analysis
Paper – IV: Generalized Hypergeometric Functions and Fractional Calculus
Paper – V: Operations Research-I
Paper – VI: Mathematical Modelling and Perturbation Methods
Paper – VII: Integral Transforms and Advanced Tensor Analysis
Paper – VIII: Advanced Graph Theory-I
Paper – IX: Relativistic Cosmology and Differential Forms

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Note:
1. There will be four hour teaching in a week per paper including dissertation.
2. For pass in course work for Ph.D. and M.Phil. course a candidate shall be required to obtain (a) at least 40% marks in each paper separately in internal assessment and external assessment and (b) a minimum of 50% marks in aggregate of all the papers prescribed for the examination (internal and external assessment taken together).

Paper – I : Research Methodology
3 hrs. Duration Theory Paper Max.Marks-80
Internal Assessment Max.Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Four Units. Two questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking one question from each Unit. All questions carry equal marks.

Unit I: Concept of Research, Types and approaches, Ethics in Research, Types and Methods of Research, Report Writing, The First Draft, title page, table of contents, headings and sub-headings, footnotes, tables and figures, appendix, References etc.

Unit II: Plagiarism checking, Editing, Post Writing Stage, Elements of Thesis, Title Page, Table of Contents, Proof Reading, Use of Computer in Research, Use of technology and other equipments in Research.

Unit III: Preparation of Power Point Presentation, Introduction to UGC INFONET, INFLIBNET and ERNET etc. Writing a Research Paper, Choosing a Topic.

Unit IV: Preparing a Working Bibliography, Use of available Computer Softwares and tools in Research

Paper – II : Analysis of Published Research Paper
(A short dissertation is to be submitted by each student under the supervision of a faculty member)

Dissertation Evaluation (External) Max.Marks-80
Internal Assessment Max.Marks -20

(Internal Assessment will be done by the supervisor concerned on the basis of the performance and aptitude towards research of the candidate)

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Paper – III: Advanced Numerical Analysis

3 hrs. Duration          Theory Paper          Max.Marks-80
Internal Assessment      Max.Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.


Unit 2: Numerical Solution of Ordinary Differential Equations – Two-Point BVPs, Difference methods – Second order, Numerov fourth order methods, Linear ordinary differential equations, Non-linear ordinary differential equations, Non-uniform grid methods for the second order BVP.

Paper – IV : Generalized Hypergeometric Functions and Fractional Calculus

3 hrs. Duration          Theory Paper          Max.Marks-80
Internal Assessment      Max.Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit 1: Genralized hypergeometric function – Definition, Convergence of the series for \( _pF_q \). Differential equation and its solution. Contiguous function relations. Saalschutz’s theorem, Whipple’s theorem. Dixon’s theorem. Contour integral representation for \( _pF_q \). Eulerian type integrals involving \( _pF_q \). Integral representation for \( _pF_q \).


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Paper-V: Operations Research-I

3 hrs. Duration  Theory Paper  Max. Marks-80  
Internal Assessment  Max. Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit 1: Theory of Games – Basic definitions, Saddle point, Optimal strategies and the value of game. Fundamental theorem of game theory. 2x2 games without saddle point. Graphical method for 2xn and mx2 games. Inventory Models – Definition, elementary inventory models e.g. EOQ model without and with shortages and EOQ with constraints.

Unit 2: Replacement and Reliability Models – Replacement of items that deteriorate, Replacement of items that fail completely and other replacement problems. Queueing Theory – Definition, Queueing system. Arrival distribution theorem, Distribution of departures, Probabilistic queueing models – Models I to IX; Mixed queueing models – Model X; Deterministic queueing model – model XI.

Paper-VI: Mathematical Modelling and Perturbation Methods

3 hrs. Duration  Theory Paper  Max. Marks-80  
Internal Assessment  Max. Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit – I: Perturbation Methods


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Unit – II : Mathematical Modelling

Paper-VII: Integral Transforms and Advanced Tensor Analysis
3 hrs. Duration Theory Paper Max.Marks-80
Internal Assessment Max.Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit – I : Integral Transforms

Unit – II : Advanced Tensor Analysis
Generalized Kronecker delta, Krutkov tensor, Ricci rotation coefficients and geometrical properties, Hypersurface, Gauss formulae, Curvature of a curve in a hypersurface, normal curvature of a hyper surface, Conformal invariance, classification of gravitational field, Space-matter tensor, Conharmonic curvature tensor, Conharmonically flat space, Symmetry, Maximally symmetric space, spherical, plane and cylindrical symmetries.

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Paper-VIII: Advanced Graph Theory-I
3 hrs. Duration
Theory Paper
Internal Assessment
Max. Marks 80
Max. Marks 20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit-I:
Graphic sequences, The Petersen graph, Cayley's formula, Matrix tree theorem, Matchings, Maximal and maximum matchings, Alternating and augmenting paths, Hall's matching condition, Marriage theorem, Vertex and edge covers, Independent sets, Algorithm for computing maximum bipartite matching, Planar embeddings, Planar graphs, Dual graphs, Outerplanar graphs.

Unit-II:
Line Graphs - Some properties of line graphs, Characterization of line graphs, Special line graphs, Line graphs and traversability. The automorphism group of a graph, Operation on Permutation groups, The group of a composite graph, Graphs with a given group, Symmetric graphs.

Paper-IX: Relativistic Cosmology and Differential Forms
3 hrs. Duration
Theory Paper
Internal Assessment
Max. Marks 80
Max. Marks 20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit 1:
Lie derivative of a Tensor field, Scalar function, Contravariant and covariant vectors, Covariant tensor of rank two, Symmetry and killing equations, Integrability of killing equation, Geodesic deviation, Conformal curvature tensor, its properties, Algebraic classification of conformal curvature tensor.

Unit 2:
Basic equations of isotropic cosmology, singularity and Singularities in isotropic models, Red Shift in non-static form of de-Sitter universe, Einstein-space, Cosmological principles (perfect, ordinary and weak), Relativistic models not obeying cosmological principle, Godel universe and its properties.

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M.Phil. Mathematics Examination 2020 and onwards

Scheme of Examination: Semesters-II

For Semester – II
3 hrs. Duration
Theory Paper Max.Marks-80
Internal Assessment Max.Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Dissertation Max.Marks-100

Teaching Pattern:
Self study with guidance from a Faculty Member, who will act as supervisor. To start with, each Supervisor will give one seminar lecture to all the students offering the paper so as to provide a model to the students.

For Semester – II,
The papers are as follows:

Paper – I : Advanced Mathematical Analysis
Paper – II : Analysis of Published Research Paper
(A short dissertation is to be submitted by each student under the supervision of a faculty member)

Each student has to opt two papers out of the following Papers III to VIII:

Paper – III : Advanced Numerical Analysis
Paper – IV : Generalized Hypergeometric Functions and Fractional Calculus
Paper – V : Operations Research-II
Paper – VI : Non-Newtonian Fluid Dynamics
Paper – VII : Advanced Graph Theory-II
Paper – VIII : Relativistic Cosmology and Differential Forms

Note:
1. There will be four hour teaching in a week per paper including dissertation.
2. For pass in course work for Ph.D. and M.Phil. course a candidate shall be required to obtain (a) at least 40% marks in each paper separately in internal assessment and external assessment and (b) a minimum of 50% marks in aggregate of all the papers prescribed for the examination (internal and external assessment taken together).

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Note: Paper I and II are compulsory and two papers out of the papers III to VIII will remain the same which the candidate opted in Semester-I.

Paper – I: Advanced Mathematical Analysis (Compulsory for all candidates)

3 hrs. Duration                         Theory Paper                Max. Marks-80
                                    Internal Assessment        Max. Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Four Units. Two questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking one question from each Unit. All questions carry equal marks.

Unit 1:

Unit 2:
Sylow’s theorem, Semigroup, Semigroup of relations on a set of Congruences, Factor groupoids and homomorphisms, Homotopy Type, The Fundamental Group, Covering Spaces.

Paper – II: Dissertation:
Each candidate has to submit a dissertation, based upon the papers opted by the candidate in M.Sc./M.Phil. Course, equal to a paper carrying 100 marks.

External Evaluation                    Max. Marks-100

Paper – III: Advanced Numerical Analysis

3 hrs. Duration                         Theory Paper                Max. Marks-80
                                    Internal Assessment        Max. Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

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\[\text{Jaipur}\]
Unit 1:
Numerical Solution of Partial Differential Equations – Classification of partial
differential equations. Finite difference approximations to derivatives, Laplace’s
equations – Five-point formula, Diagonal five point formula, Jacobi’s method, Gauss-
Seidal method and successive over relaxation methods. Parabolic equation in one space
dimension, two levels and three levels difference methods – Schmidt method,
Laasonen method, Crank-Nicolson method, Dufort and Frankel method. Hyperbolic
equation in one space dimension, Explicit three level difference scheme, Implicit
scheme, First order hyperbolic equation – Lax – Wendroff formula.

Unit 2:
Finite Element Methods – Introduction, Weighted residual methods, Variational
methods, Rayleigh-Ritz method, Galerkin method, Finite elements, Assembly of
element equation. Application of finite element method, One-dimensional and two-
dimensional problems.

Paper – IV : Generalized Hypergeometric Functions and
Fractional Calculus

3 hrs. Duration Theory Paper Max.Marks-80
Internal Assessment Max.Marks-20

(Internal Assessment will be done by Teacher concerned on the basis of test papers,
regularity in the class and performance of the Candidate).

Note: This paper is divided into Two Units. Four questions will be set from each
Unit. Candidates are required to attempt FOUR questions in all taking two
questions from each Unit. All questions carry equal marks.

Unit 1:

Unit 2:
H-function of one variable – Definition. Identities. Special cases. Differentiation
formulas. Recurrence and contiguous function relations. Finite and infinite series.
Fourier series for the H-function. Simple finite and infinite integrals involving the H-
function.
### Paper-V: Operations Research-II

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<th>3 hrs. Duration</th>
<th>Theory Paper</th>
<th>Max.Marks-80</th>
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<td>Internal Assessment</td>
<td>Max.Marks-20</td>
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(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

**Note:** This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

**Unit 1:**
Transportation Models – Mathematical formulation, Initial basic feasible solution, Optimality test, Transportation algorithm for minimization problem, Degeneracy in transportation problems, Unbalanced transportation problem.
Integer Linear Programming – Definition, Gomory’s cutting plane method, Branch and Bound method, Applications of Integer programming.

**Unit 2:**
Dynamic Programming models –Definition, Bellman’s principle of optimality, Minimum path problem, Single additive constraint- Multiplicatively and additively separable return, Single multiplicative constraint, Additively separable return, System involving more than one constraint. Applications in production, Inventory control, Linear programming and reliability. Decision Theory.

### Paper VI: Non-Newtonian Fluid Dynamics

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<th>3 hrs. Duration</th>
<th>Theory Paper</th>
<th>Max.Marks-80</th>
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<td>Max.Marks-20</td>
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(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).

**Note:** This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

**Unit 1:**
Unit 2:
Unidirectional shear flows. Form of the stress tensor. Steady shear flow material functions. Unidirectional unsteady shear flow material functions. Measurement of viscosity and normal stress coefficients in (i) Cone and plate instrument and (ii) Parallel disk instrument.

Paper-VII: Advanced Graph Theory-II
3 hrs. Duration Theory Paper Max.Marks-80
Internal Assessment Max.Marks-20
(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).
Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit-I:
Vertex cuts and edge cuts, connectivity and edge-connectivity, bonds, blocks, block-cutpoint graphs, 2-connected graphs, Menger's theorem. Total transformation graphs, Some properties of total transformation graphs.

Unit-II:
Factors, Tutte's 1-factor theorem, Berge-Tutte formula, Petersen's results on 1-factors and 2-factors. Domination Theory - Domination numbers, Some elementary properties.

Paper- VIII: Relativistic Cosmology and Differential Forms
3 hrs. Duration Theory Paper Max.Marks-80
Internal Assessment Max.Marks-20
(Internal Assessment will be done by Teacher concerned on the basis of test papers, regularity in the class and performance of the Candidate).
Note: This paper is divided into Two Units. Four questions will be set from each Unit. Candidates are required to attempt FOUR questions in all taking two questions from each Unit. All questions carry equal marks.

Unit 1:
Non-static cosmological models, Robertson-Walker model and its derivation and Geometrical properties, Fredmann-Robertson-Walker model and its scale factor, Three different forms of scale factor, Doppler effect in Robertson-Walker model, Horizons (Event and Particle), Big Bang Theroy, Steady state theory.

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Unit 2: