# DEPARTMENT OF MATHEMATICS

## Ph.D (Mathematics)

## ACADEMIC SESSION 2010 onwards

# J.C. BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY, YMCA

**J.C.BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY, YMCA FARIDABAD**
**DEPARTMENT OF MATHEMATICS**

## SCHEME OF Ph.D MATHEMATICS( Course Work)(2010)

| Subject code | Title | L | T | P | Sessional Marks | Final Exam Marks | Total | Credits | Category Code |
|---|---|---|---|---|---|---|---|---|---|
| PHAS-06 | Operation Research | 4 | 0 | 0 | 40 | 60 | 100 | 4 | DCC |
| PHAS-07 | Fixed Point Theory | 4 | 0 | 0 | 40 | 60 | 100 | 4 | DCC |
| PhD-100A | Research Methodology | 4 | 0 | 0 | 40 | 60 | 100 | 4 | DCC |

## SCHEME OF Ph.D MATHEMATICS( Course Work)(2016)

| Subject code | Title | L | T | P | Sessional Marks | Final Exam Marks | Total | Credits | Category Code |
|---|---|---|---|---|---|---|---|---|---|
| PHAS-09 | Reliability Theory and its Application | 4 | 0 | 0 | 40 | 60 | 100 | 4 | DCC |
| PhD-100A | Research Methodology | 4 | 0 | 0 | 40 | 60 | 100 | 4 | DCC |

## SCHEME OF Ph.D MATHEMATICS( Course Work)(2018)

| Subject code | Title | L | T | P | Sessional Marks | Final Exam Marks | Total | Credits | Category Code |
|---|---|---|---|---|---|---|---|---|---|
| PHDM-01 | Operation Research | 4 | 0 | 0 | 25 | 75 | 100 | 4 | DCC |
| PhD-100A | Research Methodology | 4 | 0 | 0 | 25 | 75 | 100 | 4 | DCC |

## SCHEME OF Ph.D MATHEMATICS( Course Work)(2019)

| Subject code | Title | L | T | P | Sessional Marks | Final Exam Marks | Total | Credits | Category Code |
|---|---|---|---|---|---|---|---|---|---|
| PHDM-01 | Operation Research | 4 | 0 | 0 | 25 | 75 | 100 | 4 | DCC |
| PHDM-02 | Quantum Optics | 4 | 0 | 0 | 25 | 75 | 100 | 4 | DCC |
| PhD-100A | Research Methodology | 4 | 0 | 0 | 25 | 75 | 100 | 4 | DCC |

# Syllabus of Operations Research for Ph.D Coursework

# Code: PHAS-06

## UNIT 1: Linear Programming Problem:

(i) Computational procedure of simplex method
(ii) Alternative optimum solutions: unbounded solutions, non-existing feasible solutions.
(iii) Big M method, Two phase method
(iv) Sensitivity Analysis
(v) Revised Simplex Method
(vi) Duality, Dual Simplex Method

## UNIT 2: Inventory Models

(i) Various costs
(ii) Deterministic inventory models
(iii) Single period inventory model with shortest cost
(iv) Stochastic models
(v) Application of inventory models
(vi) Economic lot sizes-price breaks

## UNIT 3: Queuing theory

(i) Introduction to Queues
(ii) Basic Elements of Queuing Models
(iii) Queue Disciplines
(iv) Role of Exponential and Poisson Distributions
(v) Markovian Process, Erlang Distribution
(vi) Distribution Of Arrivals, Distribution of Service Times
(vii) Definition of Steady and Transient State, Poisson Queues.

## UNIT 4: Integer linear programming

(i) Integer Linear Programming Problems
(ii) Mixed Integer Linear Programming Problems
(iii) Cutting Plane Method
(iv) Branch and Bound Method
(v) 0-1 integer linear programming problem.

## UNIT 5: Non linear programming & Quadratic programming

(i) Formulation of non linear programming problems
(ii) General non linear programming
(iii) Canonical form of non linear programming problem
(iv) Kuhn Tucker conditions, non negative constraints
(v) General quadratic programming problem
(vi) Wolfe's modified simplex method
(vii) Beale's method

## UNIT 6: Dynamic Programming

(i) Bellman's Principle of optimality of Dynamic Programming
(ii) Multistage decision problem and its solution
(iii) Solution of linear programming problems as a Dynamic Programming Problem

**Books**


- Hadley, G.,"Linear Programming, and Massachusetts", Addison-Wesley
- Taha, H.A, "Operations Research – An Introduction", Macmillian
- Hiller, F.S., G.J. Lieberman, " Introduction to Operations Research", Holden-Day
- Harvey M. Wagner, "Principles of Operations Rsearch with Applications to Managerial Decisions", Prentice Hall of India Pvt. Ltd.
- Swarup K., "Operations Research", S. Chand

# Syllabus for Pre-Ph.D. Programme

## Fixed Point Theory

### Section-I

Metric spaces and topological spaces, neighbourhoods, limit points, open and closed sets, completeness of metric spaces, Cantor's intersection theorem, contraction mappings, contraction principle and its converse, continuous and uniform continuous functions in metric spaces, compact metric spaces.

### Section-II

Normed linear spaces, Banach spaces, fixed points, Lipschitz, non-expansive, contractive, contraction mappings and relation between these mappings, retraction mapping, $\in$ - chain and $\in$ - chainable metric spaces. Brouwers and Schauder's fixed point theorems and applications.

### Section-III

Probabilistic metric spaces, Fuzzy Metric Spaces, Intuitionistic fuzzy metric Spaces, Various types of mappings such as commuting mappings, compatible mappings and their variants.

**Suggested books:**

1. Istratescu, V.I., Fixed Point Theory: An Introduction, Springer.

2. Joshi, M.C. and Bose, R.K., Some Topics in Non-Linear Functional Analysis, John Wiley & Sons (Asia).

3. J. Dugundji and A. Granas, Fixed Point Theory, Springer.

4. Agarwal, R.P., Meehan, M., and O' Regan, D., Fixed Point Theory and Applications, Cambridge Tracts in Mathematics, 141, Cambridge University Press.

## Reliability Theory And its Application(PHM-101)

No. of Credits: 4
L T P Total
4 0 0 4

Sessional: 40 Marks
Theory : 60 Marks
Total : 100 Marks
Duration of Exam: 3 Hours

**Part-A**

Probability generating function: Probability generating function (pgf) of Bernoulli, binomial, Poisson and geometric distributions, Mean and variance of probability distributions using pgf. Mean and variance of probability distributions in terms of Laplace transforms. Stochastic Processes: definition, classification and examples. Markov Chains: definition and examples, transition matrix, order of a Markov chain, Markov chain as graphs.

**Part-B**

Reliability and Quality. Failure Data Analysis: Failure data, Failure density, Failure rate. Some Important distributions: Exponential, Rayleigh, Weibul, Gamma and Lognormal distributions.

Laplace and Stieltjes transforms and convolutions.

Component Reliability and Hazard Models: Component reliability from test data, Mean time to failure (MTTF), Mean time between failures (MTBF), Time dependent hazard models. Bath-Tub Curve.

**Part-C**

System Reliability Models: Systems with components in series, Systems with parallel components, k-out-of-m systems, Non-series parallel systems, Systems with mixed mode failures. Standby redundancy: Simple standby system, k-out-of-n standby system.

**Part-D**

Maintainability and Availability: Maintainability function, Availability function, Reliability and availability analysis of a two-unit parallel system with repair using Markov model, Reliability and availability analysis of single-unit and two- unit cold standby systems with constant failure and repair rates using regenerative point and supplementary variable techniques.

Economics of Reliability Engineering: Manufacture’s cost, Customer’s cost, Reliability achievement and utility cost models, Depreciation cost models and availability cost model for parallel system.

**Books Recommended:**

1. E. Balagurusami, Reliability Engineering, Tata McGraw Hill, New Delhi, 1984.
2. L. S. Srinath, Reliability Engineering, Affiliated East West Press, New Delhi, 1991.
3. Elsayed A. Elsayed, Reliability Engineering, Addison Wesley Longman. Inc. Publication
4. A. Birolini, Reliability Engineering: Theory and Practical, Springer-Verlag.
5. Jai Singh Gurjar, Reliability Technology, I.K. International Publishing House Pvt. Ltd
6. Charles E Ebeling, An Introduction to Reliability and Maintainability Engineering, Tata McGraw-Hill Publishing Company Limited, New Delhi,2000

# Ph.D Coursework
# Operations Research
# Code: PHDM-01
# No of Credits: 4

| | | | |
|---|---|---|---|
| | | Sessional: | 25 |
| L | P | Theory Exam: | 75 |
| 4 | 0 | Total: | 100 |

## UNIT 1

Linear Programming Problem: Computational procedure of simplex method, Alternative optimum solutions: unbounded solutions, non-existing feasible solutions. Big M method, Two phase method, Sensitivity Analysis, Revised Simplex Method, Duality, Dual Simplex Method.

## UNIT 2

Inventory Models: Various costs, Deterministic inventory models, Single period inventory model with shortest cost, Stochastic models, Application of inventory models, Economic lot sizes-price breaks.

## UNIT 3

Assignment problem, mathematical formulation, solution of assignment problem (Hungarian method), Transportation problem, mathematical formulation. Initial basic feasible solution of transportation problem by North-west corner rule, Lowest-cost Entry method and Vogel's approximation method, Optimal solution of transportation problem.

## UNIT 4

Integer linear programming: Integer Linear Programming Problems, Mixed Integer Linear Programming Problems, Cutting Plane Method, Branch and Bound Method.

Queuing theory: Introduction to Queues, Basic Elements of Queuing Models, Queue Disciplines, Role of Exponential and Poisson Distributions, Markovian Process, Erlang Distribution, Distribution of Arrivals, Distribution of Service Times, Definition of Steady and Transient State, Poisson Queues.

Books:


- Hadley, G., “Linear Programming, and Massachusetts”, Addison-Wesley
- Taha, H.A, “Operations Research – An Introduction”, Macmillian
- Hiller, F.S., G.J. Lieberman, “Introduction to Operations Research”, Holden-Day
- Harvey M. Wagner, “Principles of Operations Rsearch with Applications to Managerial Decisions”, Prentice Hall of India Pvt. Ltd.
- Swarup K., “Operations Research”, S. Chand

**PHD – 100A**

# RESEARCH METHODOLOGY

***PhD (Common Subject)***

| | |
|---|---|
| No. of Credits: 4 | Sessional: 25 Marks |
| L \| T \| P \| Total | Theory: 75 Marks |
| 4 \| 0 \| 0 \| 4 | Total: 100 Marks |
| | Duration of Exam: 3 Hours |

**Course Objectives:**

Understand research process in order to plan a research proposal

Learn methods to devise and design a research set-up

Plan and perform data collection methods and its analysis

Conclude research in report writing

**Course Outcomes: The research scholar shall be able to**

| | |
|---|---|
| CO1 | Plan a research proposal and design the research. |
| CO2 | Collect data through experiments or surveys as per research requirement. |
| CO3 | Understand and apply sampling and sampling distributions. |
| CO4 | Understand and perform quantitative and qualitative data analysis. |
| CO5 | Write research report with proper citations. |

***Unit 1*** **Introduction to Research**: Definition, need and purpose of research, types of research, research process, approaches to research, planning a research proposal, literature review.

***Unit 2*** **Measurement Scales**: Indexes vs. Scales, Types of Scale, construction of Scale, Bogardus social distance scale, Thurstone Scale, Likert Scale, Semantic Differential Scale, Guttmann Scale.

***Unit 3*** **Data Collection Methods:** Experiments and Surveys, Experiments: Classical Experiments, Independent & Dependent Variables, Pre Testing & Post Testing, Double Blind Experiment, Subject Selection, Variation on Experiment Design. Survey Research: Topics appropriate for survey research, Guidelines for asking questions, Questionnaire Construction, Strengths & Weakness of Survey Research, Types of Surveys.

***Unit 4*** **Sampling**: Types of sampling methods: Non Probability Sampling, Probability Sampling, Theory & Logic of Probability Sampling, Sampling Distributions & Estimates of Sampling Error.

***Unit 5*** **Data Analysis**: Qualitative v/s Quantitative data analysis, Qualitative Data Analysis: Discovering Patterns, Grounded Theory Method, Semiotics, Conversation Analysis, Qualitative Data Processing. Quantitative Data Analysis: Quantification of Data, Univariate Analysis, Bivariate Analysis, Multivariate Analysis, Regression Analysis, Description Analysis. Hypothesis. Multiple Attribute Decision Making.

***Unit 6*** **Report Writing, Ethical Issues and Outcomes**: Report Preparation, Structure of Report, Report Writing Skills, Citations, Research Papers, Intellectual Property Rights, Plagiarism, Patent, Commercialization, Ethical Issues.

**References:**


1. Research Methodology by R. Panneerselvam, 2nd Ed. PHI
2. Research Methodology by C.R. Kothari & Gaurav Garg, 3rd Ed. New Age Publishers
3. Research Methodology and Scientific Writing by C. George Thomas, Ane Books
4. The practice of social research by Earl Babbie, 14th Ed. Cengage
5. Multiple Attribute Decision Making, Gwo-Hshiung Tzeng and Jih-Jeng Huang, CRC Press

**Ph. D Coursework**
**Quantum Optics**
**Code: PHDM-02**
**No. of Credits: 4**

| L | P | | |
|---|---|---|---|
| 4 | 0 | **Sessional:** | **25** |
| | | **Theory:** | **75** |
| | | **Total:** | **100** |

**Course Objectives:**To provide elementary knowledge of quantum optics and to learn about the basic concepts and techniques of quantum optics and their applications to physical systems.

**Course Outcomes: After the successful completion of the course the research scholar shall be able**

**CO1:** To learn about quantization of an electromagnetic field and the basic State space representation of the electromagnetic field.

**CO2:**To know about coherent states and its properties and to understand about the coherent state formation by applying the displacement operator over the vacuum.

**CO3:**To know about squeezed states and its properties and to understand about the squeezed state preparation by applying the squeezed operator over vacuum.

**CO4:**To learn about phase space descriptions of the electromagnetic field like P and Q representations and to know about Wigner's phase space density function.

## Unit I

Quantization of the electromagnetic field, Field quantization, Density of modes, Commutation relations, State space for the electromagnetic field: Fock space and Fock or Number states

## Unit II

States of the electromagnetic field I, Coherent states and its properties, coherent states are minimum uncertainty states, coherent states are not orthogonal, coherent states are over complete, Displacement operator and its properties, Photon statistics, Coordinate representation

## Unit III

States of the electromagnetic field II, The Squeeze operator, Squeezed states and general properties, Squeezed state is an eigen state of a generalized annihilation operator, calculation of moments with squeezed states, quadrature fluctuations, photon statistics, Multimode squeezed states

## Unit IV

Phase space description, Q-representation: anti normal ordering, Normalization, Average of anti normally ordered products, some examples, Density operator in terms of the function Q, Characteristic function, P representation: normal ordering, Normalization, Averages of normally ordered products, Some examples, Wigner distribution: symmetric ordering, Moments

**References:**


1. P. Meystre and M. Sargent, Elements of Quantum Optics, Springer-Verlag (1990).
2. D. F. Walls and G. J. Milburn, Quantum Optics, Springer-Verlag (1994).
3. G. S. Agarwal, Quantum Optics, Cambridge University Press (2013).
4. Miguel Orszag, Quantum Optics, Springer (2000).
5. M. O. Scully and M. S. Zubairy, Cambridge University Press (2012).
6. R. Loudon, The Quantum Theory of Light, Oxford Science Publications.