DEPARTMENT OF OPERATIONAL RESEARCH
FACULTY OF MATHEMATICAL SCIENCES
UNIVERSITY OF DELHI
DELHI-110 007

Details of M.Phil. Programme in Operational Research

1. **Course Structure**

   (a) There will be 3 courses for the M.Phil. Part-I. A course on Research Methodology (M.Phil.–01) is compulsory and the two courses are optional, which are to be selected out of the following 09 optional courses.

   Courses (i)-(ix) : Any two of the following

   (i)   M.Phil.–02: Inventory and Production Management

   (ii)   M.Phil.–03: Marketing Management

   (iii)   M.Phil.–04: Mathematical Programming

   (iv)   M.Phil.–05: Theory of Reliability

   (v)   M.Phil.–06: Software Reliability

   (vi)   M.Phil.–07: Queueing Systems

   (vii)   M.Phil.–08: Supply Chain Management

   (viii) M.Phil.–09: Financial Engineering

   (ix)   M.Phil.–10: Network Optimization

   (b) Dissertation (compulsory) in M.Phil. Part-II based upon preferably one of the optional courses studied by the student.

2. **Attendance**

A student admitted to the M.Phil. Part-I shall be required to attend not less than $2/3^{rd}$ of the number of contact periods and seminars held separately.

* All other rules mentioned in the Ordinance VI (notification dated 9th August, 2017) of Ordinances of the University of Delhi related to Master of Philosophy (M.Phil.)/Doctorate of Philosophy (Ph.D.) are also applicable.

3. **Duration**

The duration of M.Phil. shall be one and a half year starting from August every year. It will be a full time course with two parts.

Part-I (August to March of next year): This part will be devoted to teaching and examination of above courses.

Part-II (April to January of next year): This part will be devoted to dissertation work under an approved supervisor from the Department.

Note: Re-examination or supplementary exam of Part-I if needed will be conducted in July.

M.Phil.: 01   **Research Methodology**

Introduction To Research Methodology: Objectives and motivation in research, Research analysis, Significance of research, Types of research, Research and Scientific methods, Criteria of good research, Defining the research problem and research framework, Literature search, Report writing and interpretation- Research article ; Reviews ; Technical reports, Presentation skills, Importance and protection of intellectual property rights, Ethical issues in research (plagiarism, falsification, integrity, misleading authorship, etc.).

Data collection and related analysis: Primary and secondary data, Data collection methods, Difference between survey and experiment, Processing operations, Types of analysis, Statistical measures, Analysis of variance, Research design, measurement and scaling techniques, Computer applications.

Sampling and hypotheses testing: Sampling fundamentals, Sampling distributions, Sampling theory, Estimation, Determination of sample size, Hypotheses, Procedures for testing of hypotheses, Regression, Factor and discriminate analysis.

Suggested Books:

1. C. R. Kothari (2009), Research Methodology: Methods and Techniques, 2nd edition, New Age International Publishers
2. Donald R. Cooper, Pamela Schindler (2006), Business Research Methods, 9th Edition, Tata McGraw Hill
3. D. Howitt (2010), Introduction to Qualitative Methods in Psychology, Pearson
4. Relevant Research Papers.

M.Phil.: 02   **Inventory and Production Management**

Deterministic Inventory Lot-Size Models with Time proportional demand, Deterministic Joint replenishment policy, Inventory Control of deteriorating Items (discrete and continuous), Inventory Control under Inflationary Conditions, Inventory models with stock dependent demand, Interaction of Inventory and trade credit policies, Impact of marketing policies on Inventory decisions, Joint buyer-seller inventory model.

The Distribution free newsboy problem and its extensions.

Aggregate Production Planning**:** Fixed and Variable Work Force Model, Inventory Location Model, Production Planning with Time Varying Demand.

Suggested Books:

1. Walters, C.D.J., 2003, Inventory Control & Management, John Wiley. & Sons.
2. Heizer, J. and Render. 2001, Principles of Operations Management, Prentice Hall.
3. Zipkin, P.H., 2000, Foundations of Inventory Management, McGraw-Hill.
4. Bernard, P. 1999. Integrated inventory management (Vol. 9). Wiley.
5. Silver, E., Pyke, D., and Peterson, R. 1998. Inventory Management and Production Planning and Scheduling, John Wiley and Sons, New York.
6. Tony Wild, 1998, Best Practice in Inventory Management, John Wiley & Sons.
7. Bedworth, D. D., & Bailey, J. E. 1999. Integrated production control systems: management, analysis, design. John Wiley & Sons, Inc.
8. Plossl, G. W., 1985, Production and Inventory Control: Principles, and Techniques, Prentice Hall.
9. Relevant research papers.

M.Phil.: 03   **Marketing Management**

Consumer Behavior, Market Segmentation, Purchasing under varying Marketing Parameters viz. Price, Quality, Promotional Efforts and Distribution Expenditure, Promotional and Pricing decisions under Competition, Media Planning and Media Allocation Models, Promotional Effort Allocation Models,   The carry over effect of Advertising, Models determining the optimal return on Investment for an advertising Campaign

Diffusion of Products and Services, Diffusion of Multi-Generational Technological Innovations, Optimal timing of introduction of new Generations, Diffusion of Products with Limited Supply and Known Expiration Date

Suggested Books:

1. Gary L. Lilien, Arvind Rangaswamy, Arnaud De Bruyn, (2013), "Principles of Marketing Engineering", Decision Pro, 2nd Edition.
2. M Crawford and Anthony D Benedetto, (2006), "New Products Management", McGraw Hill Publishers, 8th Edition, Singapore.
3. Truett & Truett, (2004), "Managerial Economics", John Wiley & Sons Inc., 8th Edition.
4. Everett M. Rogers (2003), "Diffusion of Innovation", 5th Edition, Free Press, New York.
5. Related Research Papers

M.Phil.: 04   **Mathematical Programming**

Generalized Convexity: Invexity and its Generalization, Optimality and Duality under invexity.

Complementarity Problem: Linear Complementarity Problem (LCP), Applications of LCP, Complementary Pivot Algorithm and Its variants, Vertical LCP, Horizontal LCP, Generalized Leontief input-output model as vertical LCP.

Bi-Level Programming: Linear Bilevel Programming, Existence of Optimal Solutions, Optimality Conditions, Solution Algorithms.

Vector Optimization: Pareto Optimality¸ Optimality Conditions, Solution Algorithms, Interactive Approaches, Goal Programming

Suggested Books:

1. S. K. Mishra and G. Giorgi (2008), "Invexity and Optimization", Nonconvex Optimization and Its Applications, Vol. 88, Springer-Verlag.
2. R. W. Cottle, J.-S. Pang and R. E. Stone (2009), "The Linear Complementarity Problem", Classics in Applied Mathematics, SIAM Edition.
3. S. Dempe (2002), "Foundations of Bilevel Programming", Nonconvex Optimization and Its Applications, Vol. 61, Kluwer Academic Publishers.
4. K. Miettinen (1998), "Nonlinear Multiobjective Optimization", International Series in Operations Research & Management Science, Vol. 12, Springer.
5. Relevant Research Papers on the Selected Topics

M.Phil.: 05   **Theory of Reliability**

Product Life Cycle, Reliability Planning and Specification. System Reliability and Optimization: System Structure Analysis: Coherent Structures, Structures represented by Paths and Cuts, Pivotal Decomposition, Modules of Coherent Structures, Exact System Reliability, Multistate Coherent Systems. Principles of Importance Measures: Reliability importance measures, Lifetime importance measures, Structure importance measures, State – Space Method for System Reliability Evaluation, Dependent Failures: Modeling of Dependent Failures, Associated Variables, Combinatorial Reliability Optimization: Combinatorial Reliability Optimization Problems of Series Structure and Non-Series Structure, Combinatorial Reliability Optimization with Multiple choice Constraints, Optimal Redundancy Problems.

Reliability Testing: Life Testing Models, Burn-in tests, Bogey Testing.

Maintenance Models: Random Point Processes in System Replacement, Time-Based System Replacement, System Replacement Based on Cost Limits, Maintenance Models with General Degree of Repair, Inspection of Systems.

Suggested Books:

1. Kuo, W. and Zuo, M.J. (2003). Optimal Reliability Modeling-Principles and Applications. John Wiley & Sons, Inc.
2. Nakagawa, T. (2005). Maintenance Theory of Reliability. Springer Series in Reliability Engineering.
3. Pham, H. (2003). Handbook of Reliability Engineering. Springer-Verlag London Limited.
4. Ushakov, I. (2013). Optimal Resource Allocation. John Wiley & Sons, Inc.
5. Yang, G. (2007).Life Cycle Reliability Engineering. John Wiley & Sons, Inc.
6. Relevant Research Papers.

M.Phil.: 06   **Software Reliability**

Introduction to Software Reliability, Software Development Life Cycle, Software Testing (Verification & Validation), Error, failure and faults in Software, Difference between Hardware & Software Reliability

Software Reliability Growth Models (SRGMs) based on NHPP, SRGMs with Error Generation/ Imperfect Debugging, Concept of Change Point, SRGMs using Stochastic Differential Equations, Unification scheme for SRGMs, Allocation and Control of Testing Effort

Release Time Problems: When to Stop Testing Software under different criteria (cost, reliability, warranty, risk, safety), bi-criterion release policy

Modelling Software Up-gradations, testing stop time for multi up-gradations

Software Vulnerability Analysis: Problems with Definitions and Assumptions

Suggested Books:

1. P. K Kapur, H Pham, A Gupta, P. C Jha (2011), "Software Reliability Assessment with OR Applications", Springer.
2. H. Pham (2000), "Software Reliability", Springer.
3. P. K Kapur, R. B Garg, S. Kumar (1999), "Contribution to Hardware and Software Reliability" World Scientific, London.
4. Y. K. Malaiya, P Sriman (1990), "Software Reliability Models", IEEE Computers Society Press.
5. Relevant Research Papers

M.Phil.: 07   **Queueing Systems**

Stochastic processes and Markov chains (Discrete Time Markov Chains and Continuous Time Markov Chains), Characteristics of queueing systems; Little's formula, Markovian and non-Markovian queueing systems, Transient behaviour; Embedded Markov chain and its applications to M/G/1, G/M/1, and related Queueing Systems.

Networks, Series, and Cyclic Queues; Semi Markov and Markov renewal processes in Queueing.

Design and control of queues, Fluid queues.

Stochastic Petri Net Modelling and its application in Queueing, Applications of the theory to the performance modeling of computer and communication networks.

Text and references:

1. D. Gross and C. Harris, Fundamentals of Queueing Theory, 3rd Edition, Wiley.
2. B. Cooper, Introduction to Queueing Theory, 2nd Edition, North-Holland.
3. L. Kleinrock, Queueing Systems, Vol. 1: Theory, Wiley & Vol. 2: Computer Applications, Wiley.
4. R. Nelson, Probability, Stochastic Processes, and Queueing Theory: The Mathematics of Computer Performance Modelling, Springer.
5. J. Medhi, Stochastic Models in Queueing Theory, 2nd Edition, Academic Press.
6. V. G. Kulkarni, Introduction to Modeling and Analysis of Stochastic Systems, 3rd Edition, Springer.
7. Kishor S. Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, 2nd Edition, Wiley.
8. T.G. Robertazzi, Computer Networks and Systems: Queueing Theory and Performance Evaluation, 3rd Edition, Springer.

M.Phil.: 08   **Supply Chain Management**

Introduction to supply chain network, Supply chain evaluation, Supply chain decisions- strategic, tactical and operational, Supply chain strategies- push, Pull and push-pull, Bullwhip effect supply chain evaluation and performance measures.

Mathematical Programming models for supply chain planning, Design and optimization, Vendor buyer coordination, Production distribution coordination, Inventory distribution, Coordination and procurement distribution coordination, Reverse and closed loop supply chain, Green supply chain and Sustainability in supply chain.

Suggested Books:

1. S. Chopra and P. Meindl, Supply Chain Management, Upper Saddle River, N.J.: Pearson Prentice Hall, (2007).
2. D. Simchi-Levi. Designing and Managing the Supply Chain. McGraw-Hill College (2005).
3. V. V. Sople, Supply Chain Management: Text and Cases. Pearson Education India (2011).
4. A. R. Ravindran and D. P. Warsing Jr,. Supply Chain Engineering: Models and Applications. CRC Press (2012).
5. J. T. Mentzer, Fundamentals of Supply Chain Management: twelve drivers of competitive advantage. Sage Publications (2004).
6. H. F. Wang and S.M. Gupta, Green Supply Chain Management: Product life cycle approach. McGraw-Hill Professional (2011).
7. S. M. Gupta (Ed.). Reverse Supply Chains: Issues and Analysis, CRC Press (2013).
8. D. F. Blumberg. Introduction to management of reverse logistics and closed loop supply chain, CRC Press (2004).
9. Relevant research papers

M.Phil.: 09   **Financial Engineering**

Introduction to Financial Engineering, Financial securities- fixed-income securities, index linked securities, Derivative securities- Forwards, Futures, Swaps, Options; Arbitrage and Hedging, No Arbitrage pricing of forward and futures contracts, Bounds for option prices, put-call parity, Valuation of contingent claims, fundamental theorem of asset pricing, The Cox-Ross-Rubinstein (CRR) model.

Introduction to Stochastic Calculus – Martingale, Brownian motion, Ito process, Diffusion and stochastic differential equation, Ito's lemma; Black-Scholes PDE and Black-Scholes option pricing formula, Delta hedging and Greeks

Applications of optimization methods in finance: Linear programming models- asset pricing and arbitrage, Non-linear programming models- volatility estimation, Integer Programming models- constructing an index fund, Dynamic programming models- structuring asset backed securities, Quadratic Optimization: mean-variance portfolio selection (Markowitz model)

Suggested Books:

1. G. Cornuejols and R. Tütüncü (2007), Optimization Methods in Finance, Cambridge University Press.
2. T. J. Watsham and K. Parramore (1997), Quantitative Methods in Finance, International Thomson Business Press.
3. J. Hull (2014), Options, Futures and other Derivatives, 9th Edition, Prentice Hall.
4. D. G. Luenberger (2013), Investment Science, 2nd Edition, Oxford University Press.
5. P. Wilmott(2006), Paul Wilmott on Quantitative Finance (selected chapters), 2nd Edition, Wiley.
6. S. M. Ross (2011), An Elementary Introduction to Mathematical Finance, 3rd Edition, Cambridge University Press.
7. A. Hirsa, S. N. Neftci (2013), An Introduction to the Mathematics of Financial Derivatives, 3rd Edition, Academic Press
8. Relevant research papers

M.Phil.: 10   **Network Optimization**

Constrained Network Problems, Minimum Cost Flows- Optimality and Duality, Maximum Flow Problem, Network Simplex Method, Relaxation Methods for Network Flow Problems, Multi-Commodity Network Flow, Minimum Concave Cost Network Flow Problems, Network Flow Problems with General Nonlinear Arc Costs, Decomposition Methods, Optimal Flow in a Network with Gains, Applications-Project Management; Facility Layout and Location Problems

Suggested Books:

1. R. K. Ahuja, T. L. Magnanti and J. B. Orlin (1993), "Network Flows: Theory, Algorithms, and Applications", Prentice Hall, Inc.
2. D. Jungnickel (2013), "Graphs, Networks and Algorithms", Fourth Edition, Algorithms and Computation in Mathematics, Springer Heidelberg.
3. J. Lee (2004), "A First Course in Combinatorial Optimization", Cambridge Texts in Applied Mathematics, Cambridge University Press.
4. C. H. Papadimitriou and K. Steiglitz (1998), "Combinatorial Optimization: Algorithms and Complexity", Dover Publications Inc., N.Y.
5. Relevant Research Papers on the Selected Topics.