MIT SLOAN SCHOOL OF MANAGEMENT

OPERATIONS RESEARCH MASTER'S PROGRAM

FIRST SEMESTER (YEAR 1, FALL): Mathematical Foundations and Basic OR Methods

Building Analytical Excellence from Mathematical Foundations to Optimization Applications

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FIRST SEMESTER (Weeks 1-15): Foundation Sciences and OR Principles

Week 1: Introduction to Operations Research and Mathematical Foundations

Monday: Program Orientation and OR Overview

- **Morning (4 hours):**
  - Program introduction and curriculum overview
  - History and evolution of operations research
  - OR methodology and problem-solving approach
  - Introduction to OR applications across industries
- **Afternoon (4 hours):**
  - Overview of career paths in operations research
  - Campus tour of computer labs and research facilities
  - Introduction to software tools (Python, R, Excel)
  - Team-building activities and networking

Tuesday: Linear Algebra Fundamentals I

- **Morning (4 hours):**
  - Vector spaces and linear transformations
  - Matrix operations and properties
  - Systems of linear equations
  - Gaussian elimination and matrix factorization
- **Afternoon (4 hours):**
  - Eigenvalues and eigenvectors
  - Matrix decomposition techniques
  - Applications in optimization
  - Problem-solving workshop

Wednesday: Probability Theory Foundations

- **Morning (4 hours):**
  - Probability spaces and axioms
  - Random variables and distributions
  - Expectation and variance
  - Joint distributions and independence
- **Afternoon (4 hours):**
  - Conditional probability and Bayes' theorem
  - Limit theorems and convergence
  - Probability simulation exercises
  - Applications in OR contexts

Thursday: Introduction to Mathematical Programming

- **Morning (4 hours):**
  - Optimization problem formulation
  - Linear programming introduction
  - Feasible regions and optimal solutions
  - Graphical solution methods
- **Afternoon (4 hours):**
  - Mathematical modeling workshop
  - LP formulation exercises
  - Introduction to optimization software
  - Case study: Production planning

Friday: Computing for Operations Research

- **Morning (4 hours):**
  - Python programming for OR
  - NumPy and SciPy introduction
  - Data structures and algorithms
  - Mathematical computing basics
- **Afternoon (4 hours):**
  - Programming exercises
  - Implementation of basic algorithms
  - Week 1 reflection and preparation
  - Software setup and troubleshooting

Assessment for Week 1:

- Diagnostic mathematics assessment (ungraded)
- Programming exercises (completion credit)
- LP formulation homework (formative feedback)
- Reflection paper on OR career goals

Reading Materials:

- "Introduction to Operations Research" by Hillier & Lieberman (McGraw-Hill Open Learning)
- "Linear Algebra and Its Applications" by Gilbert Strang (MIT OCW)
- "Introduction to Probability" by Dimitri Bertsekas (MIT OCW)
- "Python for Data Analysis" by Wes McKinney (O'Reilly Open Books)

Week 2: Linear Programming Theory and Methods

Monday: Linear Programming Theory

- **Morning (4 hours):**
  - Standard form and canonical form
  - Basic feasible solutions
  - Fundamental theorem of linear programming
  - Vertex enumeration methods
- **Afternoon (4 hours):**
  - Geometric interpretation of LP
  - Degeneracy and multiple optima
  - Unbounded and infeasible solutions
  - Problem-solving workshop

Tuesday: Simplex Method I

- **Morning (4 hours):**
  - Simplex algorithm development
  - Simplex tableau method
  - Pivot operations and optimality conditions
  - Initial basic feasible solution
- **Afternoon (4 hours):**
  - Hand calculations practice
  - Simplex implementation
  - Cycling and degeneracy handling
  - Computational exercises

Wednesday: Statistics for Operations Research

- **Morning (4 hours):**
  - Descriptive statistics and data visualization
  - Statistical inference and hypothesis testing
  - Confidence intervals
  - Regression analysis basics
- **Afternoon (4 hours):**
  - Laboratory: Statistical analysis with R
  - Data analysis exercises
  - Statistical software introduction
  - Case studies in OR applications

Thursday: Linear Programming Applications I

- **Morning (4 hours):**
  - Production planning problems
  - Diet and blending problems
  - Transportation problems
  - Assignment problems
- **Afternoon (4 hours):**
  - Model formulation workshop
  - Case study analysis
  - Software implementation
  - Industry applications

Friday: Computational Linear Programming

- **Morning (4 hours):**
  - LP software introduction (CPLEX, Gurobi)
  - Python optimization libraries
  - Model implementation techniques
  - Sensitivity analysis
- **Afternoon (4 hours):**
  - Computer laboratory
  - LP solver comparison
  - Large-scale problem solving
  - Week 2 review and preparation

Assessment for Week 2:

- Simplex method problem set (15%)
- Statistical analysis assignment (10%)
- LP formulation and solution project (15%)
- Software implementation exercise (10%)

Reading Materials:

- "Linear Programming" by Vasek Chvatal (Open Textbook Library)
- "The Simplex Method" lecture notes (Stanford OCW)
- "Statistics for Business and Economics" (OpenStax)
- "Optimization with Python" documentation

Week 3: Advanced Linear Programming and Duality

Monday: Simplex Method II

- **Morning (4 hours):**
  - Two-phase method
  - Big-M method

    - Revised simplex method
    - Computational efficiency considerations
- **Afternoon (4 hours):**
    - Implementation workshop
    - Algorithm comparison
    - Numerical stability issues
    - Advanced problem solving

Tuesday: Duality Theory

- **Morning (4 hours):**
    - Primal-dual relationships
    - Dual problem formulation
    - Strong and weak duality theorems
    - Complementary slackness conditions
- **Afternoon (4 hours):**
    - Dual simplex method
    - Economic interpretation of duality
    - Shadow prices and sensitivity
    - Problem-solving workshop

Wednesday: Network Flow Problems I

- **Morning (4 hours):**
    - Network terminology and representation
    - Minimum cost flow problems
    - Transportation and transshipment
    - Network simplex method
- **Afternoon (4 hours):**
    - Network modeling exercises
    - Specialized algorithms
    - Computational advantages
    - Applications workshop

Thursday: Sensitivity Analysis and Parametric Programming

- **Morning (4 hours):**
    - Post-optimality analysis
    - Range of optimality
    - Range of feasibility
    - Adding/deleting constraints and variables
- **Afternoon (4 hours):**
    - Parametric linear programming
    - Sensitivity analysis tools
    - Practical interpretation
    - Case study applications

Friday: Mathematical Modeling Principles

- **Morning (4 hours):**
    - Model development process
    - Problem structuring techniques
    - Validation and verification
    - Model complexity management
- **Afternoon (4 hours):**
    - Modeling workshop
    - Team modeling exercises
    - Model critique and improvement
    - Week 3 review

Assessment for Week 3:

- Duality problems and proofs (15%)
- Network flow modeling project (15%)
- Sensitivity analysis assignment (10%)
- Mathematical modeling exercise (10%)

Reading Materials:

- "Linear Programming and Network Flows" by Bazaraa (Selected Chapters - Open Access)
- "Duality Theory" lecture notes (MIT OCW)
- "Network Optimization" by Ahuja, Magnanti, and Orlin (Selected Chapters)
- "Mathematical Modeling" by Mark Meerschaert (Academic Press Open)

Week 4: Integer Programming and Combinatorial Optimization

Monday: Integer Programming Fundamentals

- **Morning (4 hours):**
    - Integer programming formulations
    - Binary and mixed-integer models
    - Modeling techniques with integer variables
    - Logical constraints and disjunctions
- **Afternoon (4 hours):**
    - IP modeling workshop
    - Facility location problems
    - Set covering and packing
    - Knapsack problems

Tuesday: Branch and Bound Method

- **Morning (4 hours):**
    - Branch and bound algorithm
    - Branching strategies
    - Bounding techniques

    - Fathoming rules
- **Afternoon (4 hours):**
    - Implementation exercises
    - Algorithm performance analysis
    - Computational complexity
    - Software tools for IP

Wednesday: Descriptive Analytics and Data Mining

- **Morning (4 hours):**
    - Exploratory data analysis
    - Clustering techniques
    - Classification methods
    - Data preprocessing and cleaning
- **Afternoon (4 hours):**
    - Laboratory: Data mining with Python
    - Pattern recognition exercises
    - Business intelligence applications
    - Visualization techniques

Thursday: Combinatorial Optimization Problems

- **Morning (4 hours):**
    - Traveling salesman problem
    - Vehicle routing problems
    - Scheduling problems
    - Graph algorithms
- **Afternoon (4 hours):**
    - Heuristic solution methods
    - Approximation algorithms
    - Metaheuristics introduction
    - Computational exercises

Friday: Project Management and Scheduling

- **Morning (4 hours):**
    - Project network models
    - Critical path method (CPM)
    - Program evaluation and review technique (PERT)
    - Resource-constrained scheduling
- **Afternoon (4 hours):**
    - Scheduling workshop
    - Software tools for project management
    - Case study analysis
    - Week 4 review

Assessment for Week 4:

- Integer programming formulation assignment (15%)

- Branch and bound implementation (15%)
- Data mining project (10%)
- Project scheduling case study (10%)

Reading Materials:

- "Integer Programming" by Laurence Wolsey (Selected Open Chapters)
- "Combinatorial Optimization" by Cook et al. (Algorithm Repository)
- "Data Mining: Concepts and Techniques" (Open Learning Resources)
- "Project Management: The Complete Guide" (PM Open Source)

Week 5: Stochastic Processes and Queueing Theory

Monday: Introduction to Stochastic Processes

- **Morning (4 hours):**
  - Stochastic process definitions
  - Markov chains and properties
  - State classification
  - Transition matrices and steady-state analysis
- **Afternoon (4 hours):**
  - Markov chain analysis
  - Absorption probabilities
  - First passage times
  - Applications in OR

Tuesday: Queueing Theory Fundamentals

- **Morning (4 hours):**
  - Queueing system components
  - Little's law
  - Poisson processes
  - Exponential service times
- **Afternoon (4 hours):**
  - M/M/1 queue analysis
  - M/M/c queue analysis
  - Performance measures
  - System design implications

Wednesday: Advanced Queueing Models

- **Morning (4 hours):**
  - M/G/1 queues
  - G/M/1 queues
  - Network of queues
  - Priority queueing systems
- **Afternoon (4 hours):**

    - Queueing analysis workshop
    - Service system design
    - Capacity planning applications
    - Performance optimization

Thursday: Simulation Methods I

- **Morning (4 hours):**
    - Monte Carlo simulation
    - Random number generation
    - Discrete event simulation
    - Simulation methodology
- **Afternoon (4 hours):**
    - Simulation laboratory
    - Model implementation
    - Output analysis
    - Verification and validation

Friday: Inventory Theory

- **Morning (4 hours):**
    - EOQ model and variations
    - Quantity discounts
    - Stochastic inventory models
    - Multi-item inventory systems
- **Afternoon (4 hours):**
    - Inventory optimization
    - Supply chain applications
    - Case study analysis
    - Week 5 review

Assessment for Week 5:

- Markov chain analysis problems (15%)
- Queueing system design project (15%)
- Simulation implementation (15%)
- Inventory optimization assignment (10%)

Reading Materials:

- "Introduction to Stochastic Processes" by Sheldon Ross (Open Chapters)
- "Queueing Theory" by Leonard Kleinrock (Selected Open Materials)
- "Simulation Modeling and Analysis" by Averill Law (Open Learning)
- "Inventory Management" (Supply Chain Open Course)

Week 6: Nonlinear Programming Introduction

Monday: Nonlinear Programming Fundamentals

- **Morning (4 hours):**
  - Nonlinear optimization problems
  - Convex and concave functions
  - Local vs. global optima
  - Optimality conditions
- **Afternoon (4 hours):**
  - Lagrange multipliers
  - Karush-Kuhn-Tucker conditions
  - Constraint qualification
  - Problem formulation exercises

Tuesday: Unconstrained Optimization

- **Morning (4 hours):**
  - Gradient descent methods
  - Newton's method
  - Quasi-Newton methods
  - Line search techniques
- **Afternoon (4 hours):**
  - Algorithm implementation
  - Convergence analysis
  - Computational exercises
  - Performance comparison

Wednesday: Constrained Optimization

- **Morning (4 hours):**
  - Penalty and barrier methods
  - Sequential quadratic programming
  - Trust region methods
  - Interior point methods
- **Afternoon (4 hours):**
  - Implementation workshop
  - Algorithm selection criteria
  - Practical considerations
  - Software tools

Thursday: Decision Analysis I

- **Morning (4 hours):**
  - Decision theory fundamentals
  - Decision trees
  - Expected value analysis
  - Sensitivity analysis in decisions
- **Afternoon (4 hours):**
  - Multi-criteria decision making
  - Utility theory

    - Risk analysis
    - Decision modeling workshop

Friday: Forecasting Methods

- **Morning (4 hours):**
    - Time series analysis
    - Moving averages and exponential smoothing
    - Trend and seasonal models
    - ARIMA models
- **Afternoon (4 hours):**
    - Forecasting laboratory
    - Model selection and validation
    - Business forecasting applications
    - Week 6 review

Assessment for Week 6:

- Nonlinear optimization problems (15%)
- Algorithm implementation project (15%)
- Decision analysis case study (10%)
- Forecasting project (10%)

Reading Materials:

- "Nonlinear Programming" by Dimitri Bertsekas (MIT OCW)
- "Convex Optimization" by Boyd and Vandenberghe (Free PDF)
- "Decision Analysis for Management Judgment" (Open Business School)
- "Forecasting: Principles and Practice" by Hyndman (Free Online)

Week 7: Supply Chain and Logistics Optimization

Monday: Supply Chain Management Fundamentals

- **Morning (4 hours):**
    - Supply chain structure and dynamics
    - Bullwhip effect
    - Supply chain coordination
    - Information sharing impacts
- **Afternoon (4 hours):**
    - Supply chain modeling
    - Network design problems
    - Facility location optimization
    - Case study analysis

Tuesday: Transportation and Distribution

- **Morning (4 hours):**
    - Vehicle routing problems
    - Traveling salesman variations
    - Location-routing problems
    - Delivery scheduling
- **Afternoon (4 hours):**
    - Routing optimization workshop
    - Heuristic solution methods
    - Software applications
    - Industry case studies

Wednesday: Production Planning and Scheduling

- **Morning (4 hours):**
    - Aggregate production planning
    - Master production scheduling
    - Material requirements planning
    - Capacity planning
- **Afternoon (4 hours):**
    - Production optimization models
    - Scheduling algorithms
    - Manufacturing applications
    - Performance evaluation

Thursday: Quality Control and Six Sigma

- **Morning (4 hours):**
    - Statistical quality control
    - Control charts
    - Process capability analysis
    - Design of experiments
- **Afternoon (4 hours):**
    - Quality improvement workshop
    - Six Sigma methodology
    - Quality optimization
    - Case study applications

Friday: Service Operations

- **Morning (4 hours):**
    - Service system design
    - Capacity management
    - Revenue management basics
    - Service quality optimization
- **Afternoon (4 hours):**
    - Service operations workshop
    - Performance measurement
    - Service improvement strategies
    - Week 7 review

Assessment for Week 7:

- Supply chain optimization project (15%)
- Vehicle routing implementation (15%)
- Production planning assignment (10%)
- Quality control analysis (10%)

Reading Materials:

- "Supply Chain Management: Strategy, Planning and Operation" by Chopra (Open Chapters)
- "Vehicle Routing: Problems, Methods, and Applications" (Transportation Research)
- "Production and Operations Management" (Open Textbook Library)
- "Quality Control Handbook" (ASQ Open Resources)

Week 8: Financial Engineering and Risk Management

Monday: Financial Optimization

- **Morning (4 hours):**
  - Portfolio optimization
  - Mean-variance analysis
  - Capital asset pricing model
  - Risk-return trade-offs
- **Afternoon (4 hours):**
  - Portfolio construction workshop
  - Optimization under uncertainty
  - Financial modeling
  - Software applications

Tuesday: Risk Analysis and Management

- **Morning (4 hours):**
  - Risk measurement techniques
  - Value at risk (VaR)
  - Scenario analysis
  - Monte Carlo methods in finance
- **Afternoon (4 hours):**
  - Risk modeling laboratory
  - Stress testing
  - Risk optimization
  - Financial applications

Wednesday: Game Theory Fundamentals

- **Morning (4 hours):**
  - Strategic decision making

    - Nash equilibrium
    - Zero-sum and non-zero-sum games
    - Cooperative and non-cooperative games
- **Afternoon (4 hours):**
    - Game theory applications
    - Auction theory
    - Mechanism design
    - Business strategy implications

Thursday: Behavioral Operations Research

- **Morning (4 hours):**
    - Behavioral decision theory
    - Cognitive biases in decision making
    - Bounded rationality
    - Human factors in OR
- **Afternoon (4 hours):**
    - Behavioral experiments
    - Decision support systems
    - Human-computer interaction
    - Practical implications

Friday: Ethics and Professional Practice

- **Morning (4 hours):**
    - Ethical considerations in OR
    - Professional responsibility
    - Data privacy and security
    - Social impact of OR applications
- **Afternoon (4 hours):**
    - Ethics case studies
    - Professional development
    - Career planning
    - Week 8 review

Assessment for Week 8:

- Portfolio optimization project (15%)
- Risk analysis assignment (15%)
- Game theory problems (10%)
- Ethics case study analysis (10%)

Reading Materials:

- "Portfolio Selection" by Harry Markowitz (Nobel Prize Papers)
- "Risk Management and Financial Institutions" by John Hull (Open Chapters)
- "Game Theory: An Introduction" by Steven Tadelis (Open Course)
- "Ethics in Operations Research" (INFORMS Guidelines)

Week 9: Data Analytics and Machine Learning for OR

Monday: Statistical Learning Theory

- **Morning (4 hours):**
  - Supervised vs. unsupervised learning
  - Bias-variance tradeoff
  - Cross-validation techniques
  - Model selection criteria
- **Afternoon (4 hours):**
  - Machine learning workshop
  - Algorithm comparison
  - Performance evaluation
  - Python implementation

Tuesday: Classification and Regression

- **Morning (4 hours):**
  - Linear and logistic regression
  - Decision trees
  - Support vector machines
  - Ensemble methods
- **Afternoon (4 hours):**
  - Classification laboratory
  - Business applications
  - Model interpretation
  - Predictive analytics

Wednesday: Clustering and Dimensionality Reduction

- **Morning (4 hours):**
  - K-means clustering
  - Hierarchical clustering
  - Principal component analysis
  - Factor analysis
- **Afternoon (4 hours):**
  - Clustering workshop
  - Data visualization
  - Market segmentation
  - Pattern recognition

Thursday: Optimization in Machine Learning

- **Morning (4 hours):**
  - Optimization problems in ML
  - Gradient descent variations
  - Regularization techniques

    - Hyperparameter optimization
- **Afternoon (4 hours):**
    - ML optimization laboratory
    - Algorithm tuning
    - Performance optimization
    - Scalability considerations

Friday: Big Data and Analytics

- **Morning (4 hours):**
    - Big data challenges
    - Distributed computing
    - Data storage and processing
    - Analytics at scale
- **Afternoon (4 hours):**
    - Big data tools workshop
    - Cloud computing platforms
    - Real-time analytics
    - Week 9 review

Assessment for Week 9:

- Machine learning implementation project (15%)
- Classification/regression assignment (15%)
- Clustering analysis report (10%)
- Big data case study (10%)

Reading Materials:

- "The Elements of Statistical Learning" by Hastie, Tibshirani, Friedman (Free PDF)
- "Introduction to Statistical Learning" by James et al. (Free PDF)
- "Pattern Recognition and Machine Learning" by Christopher Bishop (Selected Chapters)
- "Big Data Analytics" (Open Data Science Resources)

Week 10: Advanced Topics and Integration

Monday: Robust Optimization

- **Morning (4 hours):**
    - Uncertainty in optimization
    - Robust optimization framework
    - Ellipsoidal and polyhedral uncertainty
    - Robust counterparts
- **Afternoon (4 hours):**
    - Robust optimization modeling
    - Applications in finance and operations

    - Software implementation
    - Case studies

Tuesday: Multi-objective Optimization

- **Morning (4 hours):**
    - Pareto optimality
    - Scalarization methods
    - Goal programming
    - Interactive methods
- **Afternoon (4 hours):**
    - Multi-objective modeling workshop
    - Trade-off analysis
    - Decision support tools
    - Applications

Wednesday: Metaheuristics and Evolutionary Algorithms

- **Morning (4 hours):**
    - Genetic algorithms
    - Simulated annealing
    - Tabu search
    - Particle swarm optimization
- **Afternoon (4 hours):**
    - Metaheuristics laboratory
    - Algorithm implementation
    - Parameter tuning
    - Performance comparison

Thursday: Operations Research in Healthcare

- **Morning (4 hours):**
    - Healthcare delivery systems
    - Resource allocation in hospitals
    - Scheduling medical staff
    - Emergency services optimization
- **Afternoon (4 hours):**
    - Healthcare OR workshop
    - Case study analysis
    - Policy implications
    - Quality improvement

Friday: Consulting and Communication Skills

- **Morning (4 hours):**
    - Consulting methodology
    - Client relationship management
    - Problem diagnosis
    - Solution implementation

- **Afternoon (4 hours):**
    - Presentation skills workshop
    - Technical communication
    - Report writing
    - Week 10 review

Assessment for Week 10:

- Robust optimization project (15%)
- Multi-objective optimization assignment (15%)
- Metaheuristics implementation (15%)
- Healthcare OR case study (10%)
- Consulting simulation exercise (10%)

Reading Materials:

- "Robust Optimization" by Ben-Tal, El Ghaoui, Nemirovski (Selected Chapters)
- "Multiple Criteria Decision Analysis" by Belton and Stewart (Open Chapters)
- "Metaheuristics: From Design to Implementation" by Talbi (Open Access)
- "Healthcare Operations Research" (Health OR Society Resources)

Week 11: Industry Applications and Case Studies

Monday: Manufacturing and Industry 4.0

- **Morning (4 hours):**
    - Smart manufacturing systems
    - IoT and data analytics in manufacturing
    - Predictive maintenance
    - Digital twin technology
- **Afternoon (4 hours):**
    - Manufacturing optimization workshop
    - Industry 4.0 case studies
    - Technology integration
    - Future trends analysis

Tuesday: Energy and Utilities Optimization

- **Morning (4 hours):**
    - Electric power systems
    - Renewable energy integration
    - Smart grid optimization
    - Energy trading and markets
- **Afternoon (4 hours):**
    - Energy optimization models
    - Sustainability considerations
    - Policy analysis

    - Case study applications

Wednesday: Transportation and Logistics Systems

- **Morning (4 hours):**
    - Urban transportation planning
    - Traffic flow optimization
    - Public transit systems
    - Freight transportation
- **Afternoon (4 hours):**
    - Transportation modeling workshop
    - GIS and routing applications
    - Policy implications
    - Smart city initiatives

Thursday: Telecommunications and Network Optimization

- **Morning (4 hours):**
    - Network design and capacity planning
    - Routing in communication networks
    - Quality of service optimization
    - 5G network challenges
- **Afternoon (4 hours):**
    - Network optimization workshop
    - Simulation and analysis
    - Technology trends
    - Business applications

Friday: E-commerce and Digital Platforms

- **Morning (4 hours):**
    - Online marketplace optimization
    - Recommendation systems
    - Dynamic pricing strategies
    - Platform economics
- **Afternoon (4 hours):**
    - Digital business models
    - A/B testing and experimentation
    - Customer analytics
    - Week 11 review

Assessment for Week 11:

- Industry application project (choose one domain) (20%)
- Technology trend analysis (10%)
- Case study presentation (10%)
- Digital platform optimization assignment (10%)

Reading Materials:

- "Industry 4.0: The Industrial Internet of Things" (Open Industry Resources)
- "Smart Grid: Fundamentals of Design and Analysis" (IEEE Open Access)
- "Transportation Planning and Technology" (Open Transportation Library)
- "Platform Revolution" by Parker, Van Alstyne, Choudary (Selected Chapters)

Week 12: Advanced Simulation and Modeling

Monday: Monte Carlo Methods

- **Morning (4 hours):**
  - Monte Carlo integration
  - Importance sampling
  - Variance reduction techniques
  - Markov Chain Monte Carlo
- **Afternoon (4 hours):**
  - Monte Carlo laboratory
  - Financial applications
  - Risk assessment
  - Computational efficiency

Tuesday: Discrete Event Simulation Advanced Topics

- **Morning (4 hours):**
  - Advanced simulation concepts
  - Input modeling and analysis
  - Output analysis and confidence intervals
  - Optimization via simulation
- **Afternoon (4 hours):**
  - Simulation modeling workshop
  - Complex system simulation
  - Animation and visualization
  - Validation techniques

Wednesday: System Dynamics

- **Morning (4 hours):**
  - System thinking and feedback loops
  - Stock and flow models
  - Policy design and testing
  - Business dynamics
- **Afternoon (4 hours):**
  - System dynamics laboratory
  - Model building exercises
  - Policy simulation
  - Organizational learning

Thursday: Agent-Based Modeling

- **Morning (4 hours):**
    - Agent-based modeling concepts
    - Emergent behavior
    - Social systems modeling
    - Market simulation
- **Afternoon (4 hours):**
    - ABM implementation
    - NetLogo programming
    - Complex adaptive systems
    - Applications in business

Friday: Model Integration and Validation

- **Morning (4 hours):**
    - Multi-method modeling
    - Model integration techniques
    - Verification and validation
    - Credibility assessment
- **Afternoon (4 hours):**
    - Integrated modeling workshop
    - Model documentation
    - Quality assurance
    - Week 12 review

Assessment for Week 12:

- Monte Carlo implementation project (15%)
- Discrete event simulation model (15%)
- System dynamics model (15%)
- Agent-based model (15%)
- Model validation report (10%)

Reading Materials:

- "Monte Carlo Methods in Finance" by Peter Jäckel (Selected Open Chapters)
- "Discrete-Event System Simulation" by Banks et al. (Open Learning)
- "Business Dynamics: Systems Thinking and Modeling" by John Sterman (MIT Sloan)
- "Agent-Based Modeling: A Guide for Social Scientists" (Open ABM Resources)

Week 13: Professional Development and Research Methods

Monday: Research Methodology in OR

- **Morning (4 hours):**
    - Research design and methodology
    - Literature review techniques
    - Hypothesis formulation and testing

    - Empirical research methods
- **Afternoon (4 hours):**
    - Research proposal development
    - Data collection strategies
    - Statistical analysis planning
    - Research ethics

Tuesday: Writing and Publishing in OR

- **Morning (4 hours):**
    - Academic writing skills
    - Journal paper structure
    - Peer review process
    - Conference presentations
- **Afternoon (4 hours):**
    - Writing workshop
    - Paper critique exercises
    - Presentation preparation
    - Publication strategies

Wednesday: Professional Networking and Career Development

- **Morning (4 hours):**
    - Professional organizations (INFORMS, etc.)
    - Networking strategies
    - Career paths in OR
    - Industry vs. academic careers
- **Afternoon (4 hours):**
    - LinkedIn and online presence
    - Interview preparation
    - Salary negotiation
    - Professional development planning

Thursday: Grant Writing and Funding

- **Morning (4 hours):**
    - Funding sources for OR research
    - Grant proposal writing
    - Budget development
    - Collaboration strategies
- **Afternoon (4 hours):**
    - Grant writing workshop
    - Proposal review process
    - Success strategies
    - Research project management

Friday: Final Project Preparation

- **Morning (4 hours):**

    - Final project guidelines
    - Project selection criteria
    - Methodology planning
    - Resource allocation
- **Afternoon (4 hours):**
    - Project proposal presentations
    - Peer feedback sessions
    - Advisor meetings
    - Week 13 review

Assessment for Week 13:

- Research proposal (15%)
- Academic writing assignment (10%)
- Professional development plan (10%)
- Grant proposal outline (10%)
- Final project proposal presentation (15%)

Reading Materials:

- "The Craft of Research" by Booth, Colomb, Williams (University of Chicago Press)
- "Writing for Academic Journals" by Rowena Murray (Open University)
- "A Field Guide to Grad School" (Various Open Resources)
- "Grant Writing for Dummies" by Beverly Browning (Selected Chapters)

Week 14: Capstone Project Development

Monday: Project Planning and Management

- **Morning (4 hours):**
    - Project scope definition
    - Work breakdown structure
    - Timeline development
    - Risk assessment
- **Afternoon (4 hours):**
    - Project management tools
    - Agile methodology
    - Team collaboration
    - Progress tracking

Tuesday: Data Collection and Analysis

- **Morning (4 hours):**
    - Data gathering strategies
    - Primary vs. secondary data
    - Data quality assessment
    - Exploratory analysis

- **Afternoon (4 hours):**
    - Data analysis workshop
    - Statistical software usage
    - Visualization techniques
    - Results interpretation

Wednesday: Model Development and Implementation

- **Morning (4 hours):**
    - Model selection and formulation
    - Algorithm development
    - Software implementation
    - Performance evaluation
- **Afternoon (4 hours):**
    - Implementation workshop
    - Debugging and testing
    - Optimization and tuning
    - Validation procedures

Thursday: Results Analysis and Interpretation

- **Morning (4 hours):**
    - Statistical significance testing
    - Sensitivity analysis
    - Robustness checks
    - Managerial implications
- **Afternoon (4 hours):**
    - Results presentation workshop
    - Visualization best practices
    - Storytelling with data
    - Recommendation development

Friday: Project Documentation and Presentation

- **Morning (4 hours):**
    - Technical documentation
    - User manuals and guides
    - Code documentation
    - Reproducibility considerations
- **Afternoon (4 hours):**
    - Final presentation preparation
    - Slide design and delivery
    - Q&A preparation
    - Week 14 review

Assessment for Week 14:

- Project plan and timeline (10%)
- Data analysis report (15%)

- Model implementation (20%)
- Results analysis (15%)
- Technical documentation (10%)

Reading Materials:

- "Project Management: A Guide to the Project Management Body of Knowledge" (PMI)
- "The Visual Display of Quantitative Information" by Edward Tufte
- "Made to Stick" by Chip Heath and Dan Heath
- "Presentation Zen" by Garr Reynolds (Selected Chapters)

Week 15: Final Presentations and Course Integration

Monday: Final Project Presentations I

- **Morning (4 hours):**
  - Student project presentations (Group A)
  - Peer evaluation and feedback
  - Q&A sessions
  - Presentation skills assessment
- **Afternoon (4 hours):**
  - Student project presentations (Group B)
  - Industry panel feedback
  - Best practices discussion
  - Lessons learned sharing

Tuesday: Final Project Presentations II

- **Morning (4 hours):**
  - Student project presentations (Group C)
  - Cross-disciplinary insights
  - Innovation showcase
  - Technology demonstrations
- **Afternoon (4 hours):**
  - Student project presentations (Group D)
  - Industry applications discussion
  - Future research opportunities
  - Collaboration possibilities

Wednesday: Course Integration and Synthesis

- **Morning (4 hours):**
  - OR methodology review
  - Mathematical foundations recap
  - Algorithm and software summary
  - Application domain insights

- **Afternoon (4 hours):**
    - Knowledge integration workshop
    - Concept mapping exercises
    - Problem-solving strategies
    - Cross-cutting themes

Thursday: Industry Perspectives and Future Trends

- **Morning (4 hours):**
    - Guest speaker: Industry practitioners
    - Current challenges in OR
    - Emerging technologies impact
    - Career opportunities discussion
- **Afternoon (4 hours):**
    - Future trends analysis
    - Technology roadmap
    - Skills development planning
    - Continuous learning strategies

Friday: Final Evaluation and Next Steps

- **Morning (4 hours):**
    - Comprehensive course review
    - Final examination
    - Course evaluation and feedback
    - Achievement assessment
- **Afternoon (4 hours):**
    - Second semester preview
    - Summer preparation activities
    - Internship opportunities
    - Academic and career planning

Assessment for Week 15:

- Final project presentation (25%)
- Peer evaluation of presentations (5%)
- Course integration essay (10%)
- Final examination (25%)
- Course reflection and evaluation (5%)

Reading Materials:

- "Operations Research: A Comprehensive Introduction" (Course Summary)
- "Future Directions in Operations Research" (INFORMS Publications)
- "Skills for the 21st Century OR Professional" (INFORMS Career Resources)
- "Continuous Learning in OR" (Professional Development Guidelines)

SEMESTER ASSESSMENT SUMMARY

Total Grade Distribution:

- Weekly Assignments and Problem Sets: 30%
- Midterm Examinations (2): 20%
- Capstone Project: 25%
- Final Examination: 15%
- Class Participation and Presentations: 10%

Key Learning Outcomes Achieved:

1. Master fundamental mathematical techniques for operations research
2. Formulate and solve linear and integer programming problems
3. Apply stochastic models and simulation methods
4. Implement optimization algorithms using modern software
5. Analyze real-world problems using OR methodology
6. Communicate technical results to diverse audiences
7. Conduct independent research in operations research

Preparation for Second Semester: Students will be prepared to tackle advanced topics including:

- Nonlinear and stochastic programming
- Advanced simulation and modeling
- Specialized application areas
- Independent research projects
- Industry consulting experiences