University of Isfahan

Course Outline
Railway Transportation Engineering
Graduate Program

Department of Railway Engineering and Transportation Planning
Faculty of Civil Engineering and Transportation
University of Isfahan

November 2023

Table of Contents

1. Definition and goal

Railway Transportation engineering graduate program is one of the higher education programs that its goal is training skilled experts with the necessary abilities to manage, plan, lead, design, and supervise specialized projects in railway transportation engineering.

2. Duration of Program and the structure

The average duration of this program is 2 years. Every semester lasts 16 complete weeks of education.

3. Credits

The total number of credits in the master degree program is 32 as described in Table 1.

Table 1. Course credits of Railway Transportation Engineering Graduate Program

No.	Type of courses	Credits
1	Core courses	9
2	Optional or Elective courses	15
3	Seminar*	2
4	Thesis	6
Total		32

* All graduate students are required to undertake the “Seminar” as 2 credits of their core curriculum. The purpose of this course is to learn how to research papers in reliable literature sources, review the articles and then submit a written report of the reviewed articles and present it, verbally.

The students should investigate a specific topic under the supervision of their supervisor and, at the end of the semester, submit their research report as a thesis to the supervisor, and deliver an oral presentation for the supervisor and two faculty professors appointed as a referee.

3.1 Compensatory courses of master degree program:

The graduate of different minors in railway transportation engineering as well as other majors, such as industrial engineering and mathematics, can continue their master degree in the railway

transportation engineering. Therefore, a number of courses should be successfully passed in addition to those listed in Table 1. The compensatory course credits are not counted in the transcript. Table 2 shows the list of compensatory courses for graduate program in railway transportation engineering.

Table 2. Compensation courses of MSc program in Railway Transportation Engineering

No.	Course Title	Credits
1	Train scheduling methods	3
2	Fundamentals of railway engineering	3
3	Operational research 1	3

3.2 Core and optional courses of master degree program:

The master degree program of railway transportation engineering has 4 core courses. Table 3 shows the core courses of the master degree program.

Table 4 shows the optional courses of the master degree program. All graduate students of railway transportation engineering can choose their optional courses from Table 4. Students should take 12 credits from the list of optional courses.

Table 3. Core courses of MSc program in Railway Transportation Engineering

No.	Course Title	Credits
1	Transportation economics and project evaluation	3
2	Advanced Operations Research	3
3	Transportation networks analysis	3
Total credits	9	

Table 4. Optional courses of MSc program in Railway Transportation Engineering

No.	Course Title	Credits
1	Multi-criteria decision-making methods	3
2	Data Mining and its Application in Railway	3
3	Risk management in railway transportation	3
4	Network Capacity Analysis	3
5	Information Technology (IT) in railway transportation	3
Total		15

TRANSPORTATION ECONOMICS AND PROJECT EVALUATION

BASIC INFORMATION

Course prefix, title and semester: Core, Transportation Economics and Project Evaluation, Q1

Number of credits: 3

COURSE PREREQUISITES:

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COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Nariman Nikoo
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number: +98 (31) 37935303
Email Address: n.nikoo@cet.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	40 min

COURSE OBJECTIVES

The course aims to deal with basics of transportation economics in terms of investment, costs, and transport supply and demand, especially in railway transportation.

REQUIRED STUDENT RESOURCES

References:

1- Quinet E, Vickerman RW. Principles of transport economics. Northampton, MA; 2004.
2- Hau TD. Congestion charging mechanisms for roads: an evaluation of current practice. World Bank Publications; 1992.
3- Mwase, Ngila, The Liberalization and Deregulation of the Transport Sector in Sub-Saharan Africa, in African Development Review (Abidjan), 1993.

Web links: -

Computer Software: Microsoft Office package

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Transportation economics and its role in economic development
2-4	Supply and demand in transportation: Transportation demand, price, factors affecting transportation demand, price elasticity of demand, income, income elasticity, transportation supply, supply elasticity, price elasticity of supply and its calculation methods
5-7	Transportation cost: Fixed cost, current and variable cost, cost allocation in road transportation, cost allocation in railway transportation, cost allocation in marine and air transportation, law of increasing returns
8-10	Transportation pricing: Price theory, resources allocation and maximization of benefits, cost plus pricing, transport market structure, price discrimination, common methods of pricing, pricing for railway transportation, pricing for air transportation, pricing for road transportation
11-12	Transportation investment: Importance of investment in transportation, comparison of transportation investment, transportation economics analysis, financial analysis in transportation, privatization in transportation
13	Side effect methods: Time value of money, costs of accidents, operating costs, environmental impacts, methods of economic evaluation
14	Economic evaluation methods: evaluation need and purpose (goals and application), basic approaches of comparing projects, evaluation methods
15	Freight and passenger transportation goals and policies in Iran and comparison with other countries
16	Production ability evaluation, transportation income, considered budget for Iran transportation section

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

ATTENDANCE STATEMENT

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STUDENTS WITH DISABILITIES ACT FOR STUDENTS WITH SPECIAL NEEDS STATEMENT

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APPROVED ACADEMIC HONESTY STATEMENT

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SYLLABI ON WEB PAGES

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ADVANCED OPERATIONS RESEARCH (AOR)

BASIC INFORMATION

Course prefix, title and semester: Core, Advanced Operations Research, Q1

Number of credits: 3

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ahmad Reza Jafarian-Moghaddam
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number: +983137935318
Email Address: ar.jafarian@trn.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	120 min

COURSE OBJECTIVES

This course aims to learn advanced optimization methods for linear and nonlinear mathematical models.

REQUIRED STUDENT RESOURCES

References:

1- Mokhtar S. Bazaraa, John J. Jarvis, Hanif D. Sherali, Linear Programming and Network Flows, 1990.
2- Laurence A. Wolsey, Integer Programming, John Wiley & Sons, 2020.
3- El-Ghazali Talbi, Metaheuristics: From Design to Implementation, John Wiley & Sons, 2009.

Web links: -

Computer Software: GAMS, Lingo, Matlab

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction to Linear Algebra and Vector and Matrix Spaces
2	Conditions of convexity and linear independence
3	Probability linear programming
4	Queuing System
5	Markov and non-Markov models
6	Game theory
7	Meta-Heuristics algorithms
8	Heuristic methods for solving nonlinear models
9-10	Artificial neural network algorithm
11-12	Genetic algorithm and programming
13	Simulated annealing method
14	Tabu search algorithm
15-16	Ant colony optimization

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

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TRANSPORTATION NETWORKS ANALYSIS

BASIC INFORMATION

Course prefix, title and semester: Core, Transportation networks analysis, Q1

Number of credits: 3

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Nariman Nikoo
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
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WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	40 min

COURSE OBJECTIVES

This course aims to familiarize students with the fundamentals of the network concepts, transportation networks problems and models, and the methods of solving them.

REQUIRED STUDENT RESOURCES

References:

1- Teodorovic D. Transportation Networks: A Quantitative Treatment. Taylor & Francis; 1986.
2- Bazaraa MS, Jarvis JJ, Sherali HD. Linear programming and network flows. John Wiley & Sons; 2008 Nov 4.

Web links: -

Computer Software: Microsoft Office package, optimization solvers (CPLEX)

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Networks definition and examples of its application (transportation, assignment, in direct transport, project planning, public network)
2	Network flow models with minimization of transportation cost
3	Out-of-Kilter algorithm for the network flow problems
4	Assignment problem
5	Shortest path problem
6	Find all shortest path, *k* shortest path, shortest path with fixed cost
7	Shortest chain among all nodes
8	Spanning tree
9	Critical path method in project planning
10	Travelling salesman problem
11	Multi commodity network flow problem
12	Network coverage problem
13	Equilibrium in transport networks
14	Traffic Assignment
15	Network design problem
16	Demand (O-D) estimation of traffic flow

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

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MULTI-CRITERIA DECISION-MAKING METHODS (MCDM)

BASIC INFORMATION

Course prefix, title and semester: Optional, Multi-criteria decision-making method, Q1

Number of credits: 3

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ahmad Reza Jafarian-Moghaddam
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
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WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	120 min

COURSE OBJECTIVES

This course prepares students to face real environments that deal with multiple criteria and multiple objectives.

REQUIRED STUDENT RESOURCES

References:
1- Jitesh J. Thakkar, Multi-Criteria Decision Making, Springer, 2021.
2- Alessio Ishizaka, Philippe Nemery, Multi-criteria Decision Analysis: Methods and Software, Wiley, 2013

Web links: -
Computer Software: Expert Choice, GAMS, Lingo, Matlab

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Decision making and decision environment
2	Decision analysis
3-5	Multi-objective decision making methods
6	Decision methods without the initial need for DM
7	Decision methods with a trade-off with DM
8	Decision methods under the exchange of exact data
9	Decision making methods under the exchange of implicit data
10	Goal programming
11	Multi-attribute decision making methods
12	Compensatory approach
13	Scoring Method
14	Compromise Method
15	Concordance / Out Ranking Method
16	Non Compensatory approach

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

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DATA MINING AND ITS APPLICATION IN RAILWAY

BASIC INFORMATION

Course prefix, title and semester: Optional, Data mining and its application in railway, Q2

Number of credits: 3

COURSE PREREQUISITES:

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COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Nariman Nikoo
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
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WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	40 min

COURSE OBJECTIVES

This course aims to familiarize students with the data mining algorithms and its application in railway.

REQUIRED STUDENT RESOURCES

References:

1- Han J, Kamber M. Data Mining Concepts and Techniques, ed Elsevier Inc.
2- Tan PN, Steinbach M, Kumar V. Introduction to data mining, Pearson education. Inc., New Delhi. 2006.
3- Witten IH, Frank E, Hall MA. Data Mining: Practical. Machine Learning Tools and Techniques, 2nd edition, San Francisco: Morgan Kaufman. 2005.

Web links: -
Computer Software: Microsoft Office package**,** IBM SPSS Modeler

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	History and basic concepts of data mining and machine learning
2	Data mining methodology
3	Data input types
4	Data understanding and preparation including data understanding, data preparation, data cleaning and data transformation
5	Classification algorithms with decision tree
6	Rule-based classification
7	Bayesian classification
8	Prediction by neural networks
9	Partitioning methods
10	Hierarchical methods
11	Density-based methods
12	Types of repeating patterns
13	Association rules methods
14	Application of data mining in the analysis of railway operation data
15	Application of data mining in the analysis of railway business data
16	Application of data mining in the analysis of Railway safety, incident, and track data

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

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SYLLABI ON WEB PAGES

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RISK MANAGEMENT IN RAILWAY TRANSPORTATION (RMRT)

BASIC INFORMATION

Course prefix, title and semester: Optional, Risk management in railway transportation, Q2

Number of credits: 3

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ahmad Reza Jafarian-Moghaddam
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
Phone Number: +983137935318
Email Address: ar.jafarian@trn.ui.ac.ir

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	120 min

COURSE OBJECTIVES

This course aims to explain the basic concepts of risk analysis and management in rail transportation systems, including unloading and loading, increasing employee safety, environmental protection, and improving the quality of freight transport.

REQUIRED STUDENT RESOURCES

References:

1- Paul Pritchard, Environmental Risk Management, 2012
2- Jody Zall Kusek, Marelize Goergens Prestidge, Billy C. Hamilton, Fail-Safe Management: Five Rules to Avoid Project Failure, The world bank, 2013

Web links: -
Computer Software: SPSS, Minitab, Aclaimant

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Reliability and risk assessment
2	Risk determination methods
3	Risk analysis methods (risk determination)
4	Risk analysis methods (risk analysis)
5	Risk analysis methods (analysis of results)
6	Ambiguity in decision making
7	Risk management
8	Risk in railway transportation
9-10	Risk control in routing
11	Risk of dangerous commodities transportation by railway
12-13	Rules and regulations for the freight transportation by railway
14	Risk in complex systems
15-16	Risk management software

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

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SYLLABI ON WEB PAGES

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NETWORK CAPACITY ANALYSIS

BASIC INFORMATION

Course prefix, title and semester: Optional, Network capacity analysis, Q2

Number of credits: 3

COURSE PREREQUISITES:

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COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Nariman Nikoo
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
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WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	40 min

COURSE OBJECTIVES

This course aims to familiarize students with the capacity calculation and analysis of railway tracks, stations, yard engines, and fleets and also the methods to increase their capacity.

REQUIRED STUDENT RESOURCES

References:

1- Pachl J. Railway operation and control. VTD rail publishing, 2002.

Web links: -

Computer Software: Microsoft Office package, simulation software (Arena), optimization software (CPLEX**)**

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Basic definition including railway track, railway block, railway critical block
2	Types of railway capacity and its necessity
3	Factors affecting railway capacity (infrastructural factors, traffic factors and operational factors)
4	Railway signaling and control systems, and their impact on the railway capacity
5	Time headway calculation for single and double railway tracks considering the signaling system types
6	Railway track capacity calculation methods tor single and double railway tracks considering the signaling system types
7	Railway track capacity calculation using simulation technic
8	Evaluation of the relationship among the railway timetable, the train types share (the ratio of freight and passenger trains), and railway track capacity
9	Methods of increasing the railway track capacity
10	Strategic planning for increasing railway track capacity
11	Analytical methods for calculation and analysis of the reception and dispatch railway tracks
12	Analytical methods for calculation and analysis of the shunting yards
13	Capacity determination and performance analysis of the railway stations using simulation technique
14	Capacity determination and performance analysis of the shunting yards using simulation technique
15	Methods of increasing the railway stations capacity
16	Railway capacity performance indicators and analysis of these indicators in railways

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

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INFORMATION TECHNOLOGY (IT) IN RAILWAY TRANSPORTATION (ITRT)

BASIC INFORMATION

Course prefix, title and semester: Optional, Information Technology (IT) in railway transportation, Q2

Number of credits: 3

COURSE PREREQUISITES:

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COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ahmad Reza Jafarian-Moghaddam
Office location: Faculty of Civil Engineering and Transportation, University of Isfahan, Hezar-Jerib av., Isfahan, Iran
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WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	-	-	120 min

COURSE OBJECTIVES

The aim of this course is to acquaint students with the applications, latest developments, IT planning and management in railways.

REQUIRED STUDENT RESOURCES

References:

1- Kenneth C. Laudon, Jane P. Laudon, Essentials of Management Information Systems, Pearson Education, Limited, 2011
2- Joe Peppard, John Ward, The Strategic Management of Information Systems, Wiley, 2016.

Web links: -

Computer Software: -

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	An overview of the basic concepts of information technology and information systems
2	The role of information technology in organizations
3	Strategic planning of information systems and information technology
4	Organization information structure architecture
5	The role of information technology in reengineering
6	IT asset management
7	Business and e-commerce
8	Railway intelligent transportation
9	GIS
10	Vehicle tracking systems
11	Passenger information systems including ticket sales and reservations
12	Information systems in the field of business and marketing, customer relationship management (CRM)
13	Operational information systems include operations management, scheduling, rolling-stocks operations control, and train crews
14	Maneuver information systems
15	Information systems in maintenance
16	Introducing related software

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (5%), Project (10%), Midterm (35%), Final (50%)

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SEMINAR AND RESEARCH METHOD
SRM …

BASIC INFORMATION

Course prefix, title and semester: Seminar and Research method

Number of credits: 2

COURSE PREREQUISITES:

-

COURSE CO-REQUISITES:

-

TEACHERS:

Person in charge: Dr. Ahmad Reza Jafarian-Moghaddam
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WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
2 h	-	-	60 min

COURSE OBJECTIVES

This course aims to familiar students with the research procedure, ethical principles and challenges, the scientific searching and indexing, the methods of presentation and scientific speech, and the principles of writing research proposals and thesis. Students will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests.

REQUIRED STUDENT RESOURCES

Textbooks:

References:

1- R. R. Powell and L. S. Connaway, “Basic Research Methods for Librarians”, 5th Edition (Library and Information Science Text Series), 2010.

2- R. K. Yin, “Case Study Research, Design, and Methods”, 5th Edition, Sage Publications, 2013.
3- W. K. Schuttle and E. Schuttle, “Communications Skills for the Information Age”, 3rd Edition, McGraw-Hill Book Co., 2001.
4- www.clarivate.com
5- www.scimagojr.com
6- scholar.google.com
7- www.endnote.com

Web links: -
Computer Software: Endnote, Mendeley

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Definitions and familiarity with types of research
2	Knowing the generalities and objectives of the proposal and thesis
3	Research process
4	The problem solving process
5	methods of determining the topic for research (research topic criteria)
6	Familiarity with journals and their scientific level
7	Learning the journals ranking system
8	Indices for evaluation of research
9	How to search for scientific articles
10	Citing and referencing methods
11	Literature Reviews Fundamentals
12	Principles of ethics in research
13	Introduction to essay writing
14	Knowing and working with Endnote software
15	Key points in preparing slides and verbal presentations
16	Seminar by students

EVALUATION PROCEDURES AND GRADING CRITERIA

Home works (30%), Project (70%), Midterm (-), Final (-)

ATTENDANCE STATEMENT

The course instructor must clearly inform students on the first day of class and in writing in the syllabus of their (1) policy regarding class absence and (2) policy, if any, for making up missed assignments. If class attendance is a component of the course grade, the course instructor must clearly communicate this to the class in writing in the syllabus.

STUDENTS WITH DISABILITIES ACT FOR STUDENTS WITH SPECIAL NEEDS STATEMENT

The following statement must appear on all syllabi: “Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the Disability Services Office as soon as possible.”

APPROVED ACADEMIC HONESTY STATEMENT

The following statement must appear on all syllabi: "The academic community is operated on the basis of honesty, integrity, and fair play. It applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records.

SYLLABI ON WEB PAGES

Syllabi presented on web pages shall contain the date of last update.