**Программа учебной дисциплины «Инструментальные среды для решения задач оптимизации в логистике» (Instrumental environment for solving optimization problems in logistics)**

Утверждена
Академическим советом ООП
Протокол № 38 от «30» августа 2018 г.

| | |
|---|---|
| Автор | Заходякин Г.В., ст.преподаватель, postlogist@gmail.com |
| Число кредитов | 3 |
| Контактная работа (час.) | 40 |
| Самостоятельная работа (час.) | 74 |
| Курс | 2 курс маг. |
| Формат изучения дисциплины | Лекции и практические занятия |

# 1 Course Description

This syllabus of academic discipline establishes minimum requirements for knowledge and skills of students and determines the content and the types of learning activities and assessment.

The program is designed for lecturers, teaching this discipline, teaching assistants and students of training direction 38.04.02 "Management", studying MSc program "Strategic Logistics Management", specialization «Analytical Information Systems for Logistics».

The program is designed in accordance with:

- educational standard of the Federal State Autonomous Educational Institution of Higher Education "National Research University "Higher School of Economics", training direction 38.04.02 "Management" approved 27.06.2014 (link);
- working curriculum of the University for the training direction 38.04.02 "Management", MSc program "Logistics and Supply Chain Management", approved in 2016.

# 2 Learning Objectives

The **objectives** of this course are: building skills for development and implementation of optimization-based decision support systems for logistics and supply chain management.

This course introduces students to new classes of optimization models and techniques, such as nonlinear, stochastic, multi-objective programming, as well as discrete optimization approaches based on constraint programming, local search and metaheuristics. However, the focus is not on the mathematics, but on the application of these techniques.

To implement models, students can use AMPL modeling language, or learn advanced modeling tools like AIMMS and IBM Decision Optimization supporting creation of GUI-based decision support tools. The course puts a heavy emphasis on example applications of mathematical programming and operations research for logistics management. The students can familiarize themselves with this topic by studying research literature and a library of optimization models for logistics planning.

# 3 Learning Outcomes

The course aims to build the following competences:

Students should **know** methods and algorithms for solving basic classes of mathematical programming problems, example formulations of business constraints using mathematical models, applications of mathematical programming models for logistics planning, leading schools of thought, professional communities and information sources on optimization

Students should **have practical skills** of translating business-constraints into conceptual models and mathematical formulation of these models, skills of collecting and preparing data for optimization models, working knowledge of computer tools for building optimization-bases decision support systems, skills for working with professional and research literature in applied optimization.

As a result of the discipline mastering the student acquires the following competencies:

## 4 Place of the discipline in the structure of educational program

This is an elective course for the 2nd year students of MSc program «Strategic logistics management».

The **prerequisite** for this course is working knowledge of AMPL, GLPK, AIMMS or similar modeling systems. This knowledge can be gained by completion of the course: «Optimization models for supply chain planning» offered during the first year of study, or by self-study of training materials developed for that course.

Studying the discipline requires following knowledge and competencies:

- working knowledge of building and solving optimization models for logistics planning using spreadsheets or a modeling language;
- basic data visualization skills using spreadsheets or specialized software;
- basic understanding of data storing and processing;
- proficiency in fundamental professional disciplines – logistics, inventory management, supply chain management.

The main provisions of the discipline can be used further in the study of the following subjects:

- Strategic management of logistical infrastructure
- Strategic development of distribution networks
- Optimization models for decision making in logistics and SCM
- Modern concepts of logistics processes simulation

## 5 Course Plan

| Topic[1] | Total | Class hours | Self-study |
|---|---|---|---|
| Application of mathematical programming in logistics and supply chain management | 6 | 2 | 4 |
| Computer tools for modeling and solving optimization problems | 48 | 18 | 30 |
| Data management and visualization for decision support | 24 | 8 | 16 |
| An overview of algorithms for solving linear and mixed-integer programming problems | 6 | 2 | 4 |
| Multi-objective optimization | 30 | 10 | 20 |
| **Total hours** | 114 | 40 | 74 |

[1] The teacher of course may adjust the load on selected topics within the total number of hours for reasons of feasibility and performance of the study group.

## 6 Forms of knowledge control

The course includes in-class activities and intensive self-study work. During self-study work students must learn theoretical material to perform the necessary tasks with the use of methodical developments of the Department and recommended literature, to master the technique of working with software products, as well as to carry out the practical exercises and a project dedicated to the solution of analytical problems using studied methods and tools.

Learning management system (LMS) is actively used for organizational and methodological support of the course and contains theoretical materials, practical exercises and examples. Consultations on the implementation of the project are being met through the forum of the course in the LMS.

| Control type | Control form | 1st year | | | | Deliverables |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| Current | Homework | * | | | | Problems / case studies |
| | Presentation | * | | | | 7 minutes presentation |
| Final | Project presentation and defense | * | | | | 10 minutes presentation, computer model and data files |
| | Individual assignment | * | | | | Computer model for solving assignment given, written report (5-7 pages) |

## 7 Knowledge and skills evaluation criteria

Assessment in all forms of current control are set on a 10-point scale.

## 8 Course Topics

**Topic 1. Application of mathematical programming in logistics and supply chain management**

The supply chain network. Supply chain management levels and processes. Application of mathematical modeling and optimization for supply chain management. Business cases for mathematical optimization for supply chain management. The structure of an optimization problem. Objective functions for supply chain optimization. Resources and professional communities for applied optimization and operations research.

Resources:

INFORMS video learning center, https://www.pathlms.com/informs

Shapiro J. Modeling the Supply Chain, 2nd ed. – Cengage, 2007. – 618 p.

**Topic 2. Computer tools for modeling and solving optimization problems**

Overview of modeling languages. Architecture of an optimization-based modeling system. Building blocks of an optimization problem – sets, parameters, variables, constraints and the objective. Syntax for optimization problem formulation. Feeding data into a model. Interaction with the model in AMPL. Using solvers. Displaying model components and solution results. Using variable suffixes in AMPL. Debugging models.

Resources: The AMPL book, ch. 1-4.

**Topic 3. Data management and visualization for decision support**

Reading and writing data to spreadsheets and databases. Using data visualization tools to display and analyze solutions. Building graphical user interfaces for optimization-based applications.

Resources:

The AMPL book, ch. 10.

Tableau free training videos http://www.tableau.com/learn/training

**Topic 4. An overview of algorithms for solving linear and mixed-integer programming problems**

A linear programming problem. Visualization of a two-dimensional linear programming problem. Graphical solution and sensitivity analysis techniques. The properties of a solution for a LP problem. Feasibility, optimality, binding constraints and shadow prices.

Using integer and Boolean variables for business problem formulation. Modeling discrete choice, economy of scale, fixed cost, sequencing using Boolean variables.

The working principles of branch & bound algorithm for solving integer programming problems. The MIP gap. Alternative algorithms for solving discrete optimization problems – constraint programming, local search, heuristics.

Resources: The AMPL book, ch. 20.

**Topic 5. Multi-objective optimization**

The need of multiple objective functions. Overview of approaches for solving multi-objective optimization problems. Goal programming. Pareto-optimality. Implementing multi-objective optimization algorithms in AMPL.

Resources: The AMPL book, ch. 13

## 9 Methods of Instruction

Methods of instruction used in the teaching process are focused on learning outcomes of the discipline that are determined in section 3. There are integrated traditional methods of training and active work of students during practical classes with the use of information systems.

Monitoring the quality of learning is accomplished during each training sessions.

Classes are held in computer labs that provide access to specialized software to perform the task by each student.

# 10 Guidelines for Knowledge Assessment

## 10.1 Topics of tasks for different types of current knowledge control

♦ **Topics of practical exercises and homework**

- Formulation of a mathematical optimization model given a business problem statement
- Implementation of an optimization model using a modeling language
- Formulating and solving a production planning model
- Formulating and solving a distribution planning model
- Formulating and solving a multi-period tactical planning model
- Using propositional logic to model business constraints. Converting propositions to integer programming constraints
- Formulating and solving a distribution network design model
- Solving operational planning and scheduling models
- Solving multi-objective optimization problems

♦ **Topics of presentations**

Students must choose one topic listed below to prepare a short (approx.. 7 minutes) in-class presentation. The presentation, unless stated otherwise, should cover: - the business problem/background; - goals for optimization project ; - key elements of the model developed – objective, decisions, data, constraints; you are advised to visualize model formulation as much as possible; - tools used to implement the model ; - scenarios considered; - how the results are used ; - economic impact of the project (if stated). The topics are based on published papers or presentations of operations research projects (Franz Edelman Award, Wagner's Prize, Analytics Conference held by INFORMS). Example topics:

- Integrated planning for pulp & paper industry
- Optimization models for restructuring BASF North Americas distribution System
- Optimization model for planning forest fuel logistics
- Strategic re-design of urban networks at La Poste
- Distribution network design for a pharmaceutical company
- Master planning for pulp and paper industry using AMPL
- Integrated planning for food industry using AIMMS
- Applying an integrated logistics network design and optimisation model: the Pirelli Tyre case
- Applying optimization for planning a two-phase distribution network
- Tactical supply chain planning for fruit industry
- Using optimization to schedule oil tankers

♦ **Topics of the projects**

Students carry out a project dedicated to the solution of a logistics/SCM problem of their choice using mathematical optimization. The students analyze information about a selected business problem and identify the optimization modeling approach. The model is implemented using a modeling language. The data for the model and scenario analysis is collected and prepared. The results of the project are presented in front of the class.

## 10.2 Final examination

The examination is performed in the form of:

- solving and individual assignment for development and implementation of an optimization model based on a given business problem formulation;

- delivering and defending the results of the project

# 11 Grading System

The final grade for the discipline consists of the following elements:

**Final grade = 0.4 * Accumulated Grade + 0.6 * Final examination**[2]

Accumulated Grade includes:
- Participation grade (participation in discussion, solving problems and case studies)
- Presentation

The formula for Accumulated Grade is:
- Accumulated Grade = 1/2 * Participation + 1/2 * Presentation

- Final examination includes presentation and defense of the class project and an individual modeling assignment.

The formula for Final Examination Grade is:
- Final Examination = 1/3 * Individual Assignment + 2/3 * Project presentation and defense

## 12 Literature

**Required**


1. Fourer R., Gay D.M., Kernighan B.W. AMPL: A Modeling Language for Mathematical Programming. - Second edition. - Duxbury Press / Brooks/Cole Publishing Company, 2002. – 517 p.
2. Williams H.P. Model building in Mathematical programming, 5th ed. – Wiley, 2013. – 432 p.


**Optional**


1. Bisschop J. AIMMS Optimization Modeling. – AIMMS, 2014. – 295 p.
2. Schrage L. Optimization modeling with LINGO. – LINDO Systems, 2015. – 603 p.
3. Sierksma G., Zwols Y. Linear and integer optimization. Theory and practice. – 3e. – CRC Press, 2015. – 656 p.
4. Hillier F., Lieberman G. Introduction to operations research – 10th ed. – McGraw-Hill, 2013. – 1411 p.
5. Shapiro J. Modeling the Supply Chain, 2nd ed. – Cengage, 2007. – 618 p.
6. Gass S., Fu M.C. Encyclopedia of Operations Research and Management Science. – Springer, 2013. -1641 p.
7. Goetschalckx M. Supply Chain Engineering. – Springer, 2011. – 680 p.
8. Sawik T. Scheduling in Supply Chains Using Mixed Integer Programming. – Wiley, 2011. – 492 p.
9. Watson M., Lewis S., Cacioppi P., Jayaraman J. Supply Chain Network Design: Applying Optimization and Analytics to the Global Supply Chain. -FT Press Operations Management, 2012. – 424 p.
10. Biegler L. T. Nonlinear programming. Concepts, algorithms, and applications to chemical process engineering. – SIAM, 2010. -399 p.
11. Rossi F. Handbook of constraint programming. – Elsevier, 2006. – 977 p.
12. Алексеева Е.В. Построение математических моделей целочисленного линейного программирования. Примеры и задачи: Учеб. пособие / Новосиб. гос. ун-т. . - Новосибирск, 2012. 131 с.
13. Бочкарев А. Планирование и моделирование цепи поставок. – Альфа-пресс, 2008 – 192 с.
14. Паклин Н.Б., Орешков В.И. Бизнес-аналитика: от данных - к знаниям. 2-е изд. - С-Пб. : Питер, 2012. - 704 с.
15. Сергеев В.И. Управление цепями поставок. – М.:Юрайт, 2014. – 480 с.
16. Уоллас Т., Сталь Р. Планирование продаж и операций: практическое руководство. – 3е изд. – СПб. : Питер, 2010. – 272 с.
17. Шапиро Дж. Моделирование цепи поставок / Пер. с англ. под ред. В.С. Лукинского. – СПб.: Питер, 2006. 720с


[2] The teacher, leading classes in the study group, may use other weights of the components. In this case the used weight of the components of final grade must be announced to students at the first lesson.

### 12.1 Online supporting material

LMS is used to ensure an interactive and continuous learning process. The system is used for posting of course materials, execution of projects, testing knowledge and consultation in project implementation through the forum of course

## 13 Special Equipment and Software Support

Classes are held in classrooms equipped with multimedia tools for presentations of reports and project works and computers with installed specialized software: AMPL or AIMMS, Solvers, Tableau, Microsoft Office.