MEDICAL UNIVERSITY – PLOVDIV

FACULTY OF PHARMACY

SYLLABUS

IN

MODELS IN PHARMACY

Approved by the Department Council, Protocol №109/28.10.2024

Confirmed by the Faculty Council, Protocol №??/29.10.2024

MODELS IN PHARMACY

Syllabus

Discipline	Final exam/ semester	According to the Faculty of Pharmacy curriculum of MU-Plovdiv Academic hours				ECTS	Academic hours in semester			
							I semester		II semester	
		Aauditorium	Lectures	Practices	Non-auditorium		L	P	L	P
Models in Pharmacy	IV	40	30	10	40	3,0	15	5	15	5

DISCIPLINE:
Models in Pharmacy

TYPE OF DISCIPLINE ACCORDING TO THE UNIFORM STATE REQUIREMENTS:
Elective

LEVEL OF QUALIFICATION:
Master

FORMS OF TRAINING:
Lectures, seminars, self-training

YEAR OF TRAINING:
Second

DURATION OF TRAINING:
Two semesters (III and IV)

ACADEMIC HOURS:
30 academic hours of lectures, 10 academic hours of seminars

TECHNICAL EQUIPMENT APPLIED IN THE TRAINING:
Multimedia presentations, discussions, model demonstrations, preparation for theoretical tests.

FORMS OF EVALUATION:
Testing and developing of coursework.

EVALUATION CRITERIA:
A final grade is formed from two components - a grade from the theoretical test and a grade from the coursework, taking into account the student's participation in the learning process.

ASPECTS OF EVALUATION CRITERIA:
The participation and work of the student in the classes, correct solving of the tests and the qualities of the courseworks.

SEMESTER EXAM:
Yes

STATE EXAM:
No.

LECTURER:
Professor of Mathematics

DEPARTMENT:
Medical Physics and Biophysics

ANNOTATION

To help us better understand our world, we often describe a particular phenomenon mathematically (by means of a function or an equation, for example). Such a description is called a model. Each model is an idealization of the real world and is never a completely accurate representation due to the complexity of reality. However, good modelling can be a prerequisite for valuable results and conclusions. Modelling can be used for several different reasons. How well any goal is achieved depends both on the state of knowledge about a given system and on how well the model is made.

The use of modelling techniques is becoming increasingly common in pharmaceutical science and industry, covering a wide range of application areas: drug discovery, pharmacokinetics and pharmacodynamics, effect of pH, creation of different dosage forms, and others. The different modelling approaches can be classified into two main categories, namely, physics-based models and empirical models. According to the nature of the modeled object, two types of models are distinguished: deterministic and stochastic. Each model goes through different stages of development: calibration, validation, verification, and maintenance.

The aim of this course is the students to gain insight into using mathematics as a tool to model, understand and interpret pharmaceutical processes. Students will be introduced to existing models with applications in pharmacy, as well as informed about the necessary knowledge to build a conceptual model: identify a problem, collect data, propose a model, test assumptions, refine the model and critically analyse the achieved results.

BASIC AIMS OF THE DISCIPLINE

The main tasks of the educational process in this discipline are the following:

- knowledge acquisition about mathematical models of real processes and especially of living systems;
- familiarization with the use of mathematical tools for interpreting processes in nature and their use for developing and improving their applications in pharmacy;
- acquisition of basic skills for applying the studied methods for developing a conceptual model with applications in pharmacy;
- knowledge of the main theoretical statements and mastering of these methods for solving practical tasks related to them.

EXPECTED RESULTS

After the training completion, students must have the following knowledge and skills:

- to know basic theoretical facts related to concepts, methods and models for interpretation of living systems;
- to be familiar with various mathematical models, their characteristics and applications;
- to have a basic ability for solving ordinary differential equations, applicable to the studied models;
- to know the basic concepts of probability theory and to be able to interpret it;
- to be familiar with the basic methods of statistical data analysis and to be able to apply them at an elementary level;
- to be able to use mathematical literature and electronic resources to expand their knowledge and skills on the subject.

LECTURES

1. Fundamentals of mathematical modelling. (4h)
   - 1.1. Concept of model. Objects, goals, and methods of modelling.
   - 1.2. Models in different sciences. Examples of models.
   - 1.3. Types of models: physical, mathematical, and computer.
   - 1.4. Modern classification of mathematical models in biology and medicine. Regression and simulation models.
   - 1.5. Principles of simulation modelling. Basic stages in building simulation models.
   - 1.6. Specificity in real processes modelling and living systems modelling.
     - 1.6.1. Complex systems.
     - 1.6.2. Reproduction systems.
     - 1.6.3. Open systems.
2. Models of living systems described by a first-order differential equation. (6h)
   - 2.1. Models reduced to a differential equation.
   - 2.2. Concept of solution of an autonomous differential equation.
   - 2.3. State of equilibrium.
   - 2.4. Stability of equilibrium results.
   - 2.5. Analytical method for studying the stability of the state of equilibrium.
   - 2.6. Linearization in the neighbourhood of the state of equilibrium.
   - 2.7. Examples: growth of colonies of microorganisms, substance in solution.
   - 2.8. Population models.
     - 2.8.1. Exponential growth equations.
     - 2.8.2. Bounded growth equations.
     - 2.8.3. Critical community size model.

        2.8.4. Population models with growth arrest.
3. Models of living systems described by a system of two autonomous differential equations. (5h)
    3.1. Phase plane and phase portrait.
    3.2. Method of isoclines. Main isoclines.
    3.3. Steady-state stability.
    3.4. Types of singular points: node, saddle, focus, center.
    3.5. Lyapunov method for linearization of the system in the neighbourhood of the steady state.
    3.6. Method of Lyapunov functions.
    3.7. Examples of studying steady-state stability in models of living systems. Lotka equations. Volterra equations.
4. Analysis of modelling results. (5h)
    4.1. Generative models for discrete data.
        4.1.1. Poisson model.
        4.1.2. Binomial model.
        4.1.3. Multinomial model.
    4.2. Statistical modelling.
    4.3. Mixed model.
    4.4. Data clustering.
5. Hypothesis testing, design, and analysis of experiments. (5h)
    5.1. Hypothesis testing – a scientific process.
    5.2. Categorization of existing types of experiments.
    5.3. Creating an effective workflow design.
6. Models in pharmacy. (5h)
    6.1. Modelling techniques in pharmaceutical science and industry.
    6.2. Models in drug discovery.
    6.3. Models in pharmacokinetics and pharmacodynamics.
    6.4. Models for the effect of pH.
    6.5. Models for creating different pharmaceutical forms.

PRACTICES

1. Differential equations of first order admitting an analytical solution. (2h)
    1.1. Equations with separable variables.
    1.2. Linear differential equation.
    1.3. Logistic equation.
2. Linear systems of ordinary differential equations. (3h)
    2.1. Calculating eigenvalues of a square matrix.
    2.2. Solving linear systems for different variants of the eigenvalues.
    2.3. Systems of linear chemical reactions.
3. Probability correlation analysis. (3h)
    3.1. Definition and basic characteristics of a random variable.
    3.2. Calculation of covariance and correlation coefficient of two random variables.
4. Preparation for course work "Creating a conceptual model with application in pharmacy". (2h)
    4.1. Setting a specific topic for the coursework.
    4.2. Providing guidance for coursework development.

BIBLIOGRAPHY

1. Banerjee, S. “Mathematical Modelling. Models, Analysis and Applications”, CRC Press, 2014.
2. Bender, E.A. “An introduction to mathematical modelling”, Wiley, New York, 1978.
3. Cobelli, C., Carson, E. “Introduction to Modelling in Physiology and Medicine”, Second Edition, Academic Press, Elsevier, 2019.
4. Cross, M., Moscardini, A.O. “Learning the art of mathematical modelling”, Ellis Horwood Ltd., Chichester, 1985.
5. Giordano, F., Fox, W., Horton, S. “A first course in mathematical modelling”, Fifth Edition, Brooks/Cole, Boston, 2013.
6. Kourti, T. “Pharmaceutical manufacturing: The role of multivariate analysis in design space, control strategy, process understanding, troubleshooting, and optimization”, Chemical Engineering in the Pharmaceutical Industry: R&D to Manufacturing, Am Ende, D.J. (editor), John Wiley & Sons, Inc., Hoboken, 2011.
7. Ravishanker, N., Dey, D. “A first course in linear model theory”, Texts in Statistical Science, CRC Press, 2002.

CONSPECTUS

1. Concept of model. Objects, goals, and methods of modelling. Models in different sciences. Examples of models.
2. Types of models: physical, mathematical, and computer. Modern classification of mathematical models in biology and medicine. Regression and simulation models.
3. Principles of simulation modelling. Basic stages in building simulation models.
4. Specificity in the modelling of real processes and living systems. Complex, reproduction, and open systems.
5. Models of living systems described by a first-order differential equation. Concept of solution of an autonomous differential equation.
6. State of equilibrium of a differential equation of the first order. Stability and analytical method for studying stability. Linearization.
7. Population models. Equations for exponential and bounded growth. Critical community size model. Population models with growth arrest.
8. Models of living systems described by a system of two autonomous differential equations. Phase plane and phase portrait. Method of isoclines.
9. Steady-state stability of a system of two autonomous differential equations. Types of special points.
10. Lyapunov method for linearization of an ODE system and method of Lyapunov functions.
11. Investigation of the steady-state stability in models of living systems.
12. Examples of studying steady-state stability in models of living systems. Lotka equations. Volterra equations.
13. Analysis of modelling results. Generative models for discrete data: Poisson, binomial, multinomial.
14. Statistical modelling. Mixed model. Data clustering.
15. Hypothesis testing. A scientific process. Categorization of experiments.

16. Design and analysis of experiments. Creating an effective workflow design.
17. Models in pharmacy. Modelling techniques in pharmaceutical science and industry.
18. Models in drug discovery and in the creation of different pharmaceutical forms.
19. Models in pharmacokinetics and pharmacodynamics and for the effect of pH.