Course Specifications
Valid as from the academic year 2019-2020

Control of Drug-delivery Systems (E027790)

Course

Lecturers in academic year 2019-2020
Ionescu, Clara-Mihaela TW08 lecturer-in-charge
Copot, Dana TW08 co-lecturer

Offered in the following programmes in 2019-2020
Master of Science in Biomedical Engineering 4 A
International Master of Science in Biomedical Engineering 4 A
Master of Science in Biomedical Engineering 4 A

Teaching languages
English

Keywords
first order - second order- higher-order compartmental models, pharmacokinetic model, pharmacodynamic model, transfer function, drug effect, synergy, population dynamics, diffusion rate, clearance rate, bolus, infusion rate, saturation, patient safety, monitoring for control, closed loop regulation, linear control, multivariable control, stability, frequency response, time response

Position of the course
The purpose of this course is to introduce the emerging topic of computer assisted drug delivery systems, in other words to introduce the recently developed strategies for population models and controls for biomedical applications. The particular focus of the course is drug delivery systems, as they are ubiquitous, as in general anesthesia, diabetes, cancer and chronic pain therapies (to mention a few examples). Two aspects are emphasized
i) The learning and application thereof methods to model and identify models for control purposes from limited data from patients
ii) The learning and application thereof techniques of control for intravenous, oral or aerosol delivery of drugs in therapy

Contents
• The role of process dynamics and control in drug delivery systems
• Computer control of biomedical processes (revisit Z transform, sampling, Fourier transform): digital delay, discretization, accuracy/resolution
• Modelling and identification: pulse transfer function, pharmacokinetics (PK), pharmacodynamics (PD), linearization, transfer function (TF), Mittal Leffler function for drug absorption and clearance
• Analysis of dynamic behaviour, synergy effects, antagonist effect of medication and interaction modelling
• What implies inter-patient and intra-patient variability in terms of models for control
• Drug trapping and risk for over-dosing - non-homogeneous diffusion in compartments
• Control design based on graphical tools, control design based on specifications (patient safety, tolerance interval, time to target settling time, nadir limitations etc)
• Multivariable system analysis and control techniques to simplify loop interactions

(Approved)
• Optimal control of drug delivery rates for positive systems (only input of drug can be manipulated, one cannot take out drug from the body with a controlled signal)

Examples in the course originating from:
• Compartmental models’ analysis for control
• Glycolytic reaction and oscillation
• Constant/variable-rate intravenous infusion
• Controlled release systems
• Control of infusion of vasoactive drugs
• Depth of anesthesia regulation

Initial competences
• Biomedical signals and systems
• Modelling Physiological Systems

Final competences
1. Understand the effect of computer digitization in the medical platform
2. Develop a mathematical model from available (limited) signals (PK, PD, TF)
3. Design a basic controller for required performance specifications
4. Critically evaluate trade-off between safety/performance and positive systems (one can only put drug into the patient, not take out)
5. Understand the difference between basic control (PID control) and optimal control (constrained based)
6. Understand interactions of various drugs and their effect in the body
7. Simplify interactions and complexity for purpose of control
8. Communicate results in an efficient manner and work in group to achieve goals
9. Make use of basic software (of choice Maple, Mathematica, Matlab, etc) to verify assumptions

Conditions for credit contract
Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract
This course unit cannot be taken via an exam contract

Teaching methods
Guided self-study, group work, seminar

Extra information on the teaching methods
Groupwork (projects), lectures, self-study with materials

Learning materials and price
Syllabus and slides freely available in electronic learning platform, software worked out solutions, textbook available for consultation

References
Laurent Simon, Wiley press, Control of biological and drug-delivery systems (for chemical, biomedical and pharmaceutical engineering), 2013

Course content-related study coaching

Evaluation methods
end-of-term evaluation and continuous assessment

Examination methods in case of periodic evaluation during the first examination period
Written examination, open book examination

Examination methods in case of periodic evaluation during the second examination period
Written examination, open book examination

Examination methods in case of permanent evaluation
Report

Possibilities of retake in case of permanent evaluation
not applicable

Extra information on the examination methods
• Evaluation during semester: project report
• Evaluation during exam period: open book written exam

Calculation of the examination mark
• From project 40% and from exam 60% final mark
• Students who have less than 10/20 for one of the parts cannot successfully pass the
complete course: if the final score is nevertheless 10 or higher/20, it will be reduced to the highest no-pass score, i.e. 9/20.