Last updated: Wednesday 7 September, 2016

Faculty of Engineering
Department of Mechanical Engineering

BIOMEDICAL SYSTEM DYNAMICS
MCG3305A
Davide Spinello
Fall 2016

Course Hours

Thursday 08:00 - 10:00
Location: STE-2052
Type: LAB 1

Thursday 08:00 - 10:00
Location: STE-2060
Type: LAB 2

Wednesday 10:00 - 11:30
Location: SCS-E217
Type: LAB 3

Friday 08:30 - 10:00
Location: SCS-E217
Type: LEC 1

Professor

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Course Description

Modeling of mechanical, fluid, thermal and biomedical systems using a lumped parameter approach. Concepts of through and across variables in systems. Block diagrams for system representation. Linearization and solution of system equations. Transient and frequency response of biomedical systems.

General and Specific Objectives

At the end of the course the students are expected to be able to analyze and to solve basic design problems in the following topics:

- Dynamical system and transfer function representation.

- Linearization and state space representation.
- Modeling and representation of mechanical, electrical, thermal and fluid systems.
- Modeling and representation of a class of biomedical systems through electric and thermo, fluid, and solid mechanical analogues.
- Basic properties of transient responses of linear time invariant systems.

Required Material

- The textbook in the Section "Monographies" is mandatory. In the course calendar, sections of the book that cover lectures' material are referenced by numbers in square brackets.
- Additional material extracted from the textbook listed in "Documents and Articles on the Web" will provided by the instructor to cover biomedical systems. It is referenced as "[provided material]" in the course calendar.

Evaluations

Problem Set

Evaluation Date: Ongoing
Evaluation Percentage: 16

Homework assignments are individual and they are instrumental to prepare for exams, as they cover in an advanced way topics addressed in class. There are 4 assignments during the term, each weighting 4% of the final grade.

Written exam (e.g. exam, long answer)

Evaluation Date: Friday 21 October, 2016
Evaluation Percentage: 24

Midterm exam. The exam is in class, open book and open notes. Electronic devices are not allowed. The exam covers the material developed in class up to Lecture 11. For additional information, see the course calendar.

Written exam (e.g. exam, long answer)

Evaluation Date: Final Exam Period
Evaluation Percentage: 60

Final Exam - Room TBD. The exam is open book and open notes. Electronic devices are not allowed. The exam will may cover all material developed in class.

Course Calendar

Wednesday 7 September, 2016	**Lecture 1** • Introductory concepts. • Tranfer functions and impulse-response function [2-2].
Friday 9 September, 2016	**Lecture 2** • Tranfer functions and impulse-response function [2-2]. • Block diagrams and basic operations [2-3]. *Suggested problems: B-2-1, B-2-2, B-2-4.*

Wednesday 14 September, 2016	**Lecture 3** • Modeling in state space [2-4]. • State-Space Representation of Scalar Differential Equation Systems [2-5]. *Suggested problems: B-2-8, B-2-9, B-2-10, B-2-11, B-2-12.*
Friday 16 September, 2016	**Lecture 4** • Linearization of nonlinear mathematical models [2-7]. *Suggested problems: B-2-13, B-2-14.*
Wednesday 21 September, 2016	**Lecture 5** • Modeling of mechanical systems [3-2].
Friday 23 September, 2016	**Lecture 6** • Modeling of mechanical systems [3-2]. *Suggested problems: B-3-1, B-3-2, B-3-3, B-3-4, B-3-6.*
Wednesday 28 September, 2016	**Lecture 7** • Respiratory system: models of chest wall mechanics. [Kutz: Section 5.4; Ref. 1 and 2].
Friday 30 September, 2016	**Lecture 8** • Modeling of electrical systems [3-3]. *Suggested problems*: B-3-7, B-3-8, B-3-9, B-3-13.
Wednesday 5 October, 2016	**Lecture 9** • Circulatory system. • Linear analog models [Kutz: Chapter 3].
Friday 7 October, 2016	**Lecture 10** • Servomotor analysis [Problem B-3-13]. • Electrical-mechanical analogy [Example A-3-4].
Wednesday 12 October, 2016	**Lecture 11** • Liquid level systems [4-2]. *Suggested problems: B-4-1.*
Friday 14 October, 2016	**Lecture 12** • Pneumatic systems [4-3].
Wednesday 19 October, 2016	**Lecture 13** • **Midterm exam.** The exam is scheduled in the lecture room, with the same duration as the lecture.
Friday 21 October, 2016	**Lecture 14** • --
Wednesday 2 November, 2016	**Lecture 15** • Pneumatic systems [4-3]. • McKibben model of pneumatic artificial muscles [Ref. 3]. *Suggested problems: A-4-4, B-4-3.*
Friday 4 November, 2016	**Lecture 16** • Thermal systems [4-5].
Wednesday 9 November, 2016	**Lecture 17** • Thermal systems [4-5]. • Lumped parameter model of cold stressed fingertip, and vascular reactivity in the fingertip [Refs. 4 and 5]. *Suggested problems: A-4-10, A-4-11, B-4-12.*
Friday 11 November, 2016	**Lecture 18** • PID controllers transfer functions [2-3]. • Pneumatic controller devices [4-3].

Wednesday 16 November, 2016	**Lecture 19** • Pneumatic controller devices [4-3]. *Suggested problems: A-4-5, B-4-3, B-4-4.*
Friday 18 November, 2016	**Lecture 20** • Transient response of first order systems [5-2].
Wednesday 23 November, 2016	**Lecture 21** • Transient response of first order systems [5-2]. *Suggested problems: A-5-1, B-5-1.*
Friday 25 November, 2016	**Lecture 22** • Transient response analysis of second order systems [5-3].
Wednesday 30 November, 2016	**Lecture 23** • Transient response analysis of second order systems [5-3]. *Suggested problems: A-5-5, A-5-7, A-5-9, A-5-14, B-5-2, B-5-3, B-5-4, B-5-5, B-5-6,B-5-10, B-5-11.*
Friday 2 December, 2016	**Lecture 24** • Second-order systems and transient response specifications [5-3]. *Suggested problems: B-5-12, B-5-15, B-5-16, B-5-18, B-5-19.*

Other Information

At the beginning of the course the students are assumed to be familiar with the theory of ordinary differential equations and with Laplace transforms. You are strongly encouraged to review the related material from pre-requisite courses.

Monographs

- Ogata, K.: *Modern control engineering - Fifth edition*. Prentice Hall, 2009.
- M. Kutz, Editor: *Biomedical engineering and design handbook. Fundamentals. Vol.1*. Second Edition. McGraw Hill. (See below for the link to uOttawa library online resource.)

Scientific Articles

1. F. P. Primiano Jr, 1982: Theoretical analysis of chest wall mechanics. *Journal of Biomechanics*, **15**(12) 919-931.
2. P. T. Macklem, D. M. Macklem, A. De Troyer, 1983: A model of inspiratory muscle mechanics. *Journal of Applied Physiology*, **55**(2) 547-557.
3. C.-P. Chou, B. Hannaford, 1996: Measurement and modeling of McKibben pneumatic artificial muscles, *IEEE Transactions in Robotics and Automation*, **12**(1) 90-102.
4. A. Shitzer, L. A. Stroschein, R. R. Gonzalez, K. B. Pandolf, 1996: Lumped-parameter tissue temperature-blood perfusion model of a cold-stressed fingertip, *Journal of Applied Physiology*. **80**(5) 1829-1834.
5. O. O. Ley, C. C. Deshpande, B. B. Prapamcham, M. M. Naghavi, 2008: Lumped Parameter Thermal Model for the Study of Vascular Reactivity in the Fingertip, ASME Journal of Biomechanical Engineering. **130**(3) 031012-031012-13.

Documents and Articles on the Web

- M. Kutz, Editor: *Biomedical engineering and design handbook. Fundamentals. Vol.1*. Second Edition. Link to uOttawa library online resource (maximum 5 concurrent users).
- Matlab online tutorial.

Plagiarism

Beware of academic fraud!

Academic fraud is an act by a student that may result in a false evaluation (including papers, tests, examinations, etc.). It is not tolerated by the University. Any person found guilty of academic fraud will be subject to severe sanctions.

Here are some examples of academic fraud:

- Plagiarism or cheating of any kind;
- Present research data that has been falsified;
- Submit a work for which you are not the author, in whole or part;
- Submit the same piece of work for more than one course without the written consent of the professors concerned.

Please consult this webpage: it contains regulations and tool to help you avoid plagiarism.
An individual who commits or attempts to commit academic fraud, or who is an accomplice, will be penalized. Here are some examples of possible sanctions:

- Receive an “F” for the work or in the course in question;
- Imposition of additional requirements (from 3 to 30 credits) to the program of study;
- Suspension or expulsion from the Faculty.

You can refer to the regulations on this webpage.

Student Services

Academic Writing Help Centre
At the AWHC you will learn how to identify, correct and ultimately avoid errors in your writing and become an autonomous writer.
In working with our Writing Advisors, you will be able to acquire the abilities, strategies and writing tools that will enable you to:

- Master the written language of your choice
- Expand your critical thinking abilities
- Develop your argumentation skills
- Learn what the expectations are for academic writing

Career Services
Career Services offers various services and a career development program to enable you to recognize and enhance the employability skills you need in today's world of work.

Counselling Service
There are many reasons to take advantage of the Counselling Service. We offer:

- Personal counselling
- Career counselling
- Study skills counselling

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