Scaling in Engineering Systems

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| **Term** | Fall 2020-2021 |
| **Course Code**  | ME435 |
| **Level of course (undergraduate/graduate)** | Senior undergraduate |
| **Course title in Turkish** | Mühendislik Sistemelerinde Ölçekleme |
| **Course title in English** | Scaling in Engineering Systems |
| **SU/ECTS Credits** | 3/6 |
| **Course Summary / Content in Turkish** | Bu ders çok ölçekli sistemler dahil farklı uzunluk ölçeklerindeki mühendislik sistemleri (nano-, mikro-, veya makro-ölçekler) için ölçeklendirme yasalarını tanıtmaktadır. Sistem modelleme, tasarım ve imlat süreçlerinde ölçeklendirme ve farklı uzunluk ölçekleri ön plana çıkmaktadır. Bu ders farklı uygulama örnekleri ile ölçeklendirmenin temel özellikleri, tasarım kuramları, modelleme yöntemleri ve üretim konularını kapsamaktadır. Mühendislik sistemlerine örnek olarak mikro-/makro-robotik, mikro-/makro-aktüatörler, MEMS, mikroakışkanlar, mikromanipülatörler (AFM, mikroenjeksiyon teknolojileri), robotic cerrahi (da Vinci Robotları), biyosensörler, MR makineleri ve güneş enerjisi panelleri ele alınmaktadır. Öğrenciler problem çözme, sanayi ve tıp alanlarından uzman kişilerle yapılan bilimsel tartışmalar, projelerinin hazırlık ve sunumları ile hem teknik hem de sunum yeteneklerini geliştireceklerdir. |
| **Course Summary / Content in English** | The course introduces the scaling laws for engineering systems including multi-scale systems consist of different length scales (nano-, micro-, or macro-scales). When system modeling, design and fabrication processes are being performed scaling and interaction of different length scales becomes prominent. This course covers the fundamental properties of scales, design theories, modeling methods and manufacturing issues with different application examples. Examples of engineering systems include micro-/macro-robotics, micro-/macro-actuators, MEMS, microfluidics, micromanipulators (AFM, Microinjection technologies), robotic surgery (da Vinci Robots), biosensors, MRI machines, and solar energy panels. Students master the materials through problem sets, scientific discussions with specialists from industry or medicine, and project preparation and presentations. |
| **Learning Outcomes** | The participants of this course will learn:1. Practical problem-solving experience using scaling laws paired with a detailed discussion of experimental techniques to probe, understand, and design the ultimate structure of different engineering systems.
2. How to use the scaling tools to predict mechanical, electrical, thermal, optical, electromagnetic properties such as strength, deformability, elasticity, thermal capacity, etc.
3. How to use multiscale tools to combine different engineering systems.
4. Demonstrate the effect of scaling computationally-designed systems using 3D printing and other macro or micro manufacturing techniques, followed by an application either for industrial, medical, or energy field. Includes validations of scaling effects.
5. The fundamentals, simulations, processes of manufacturing and experimental applications to perform state-of-the-art techniques, such as micro surgery, MR imaging used to cover a range of length- and time-scales.
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| **Prerequisites / Corequisites** | There are **neither** prerequisites **nor** corequisites for this course. |
| **Registration constraints** |  Max 30 people |
| **Program Requirements (Core, Area, Free elective etc.)** |  |
| **Reason for proposing the course** | To create a platform and provide conditions that is necessary to combine interested scientists and engineers working in the areas of mechatronics, biology, electronics, material science, manufacturing systems who are interested in understanding how to use scaling laws to improve engineering system’s performance, multi- functionality, robustness, intelligent, while decreasing the cost. In addition, to be able to provide full responsibility to students in order to start, progress, result and report their projects for a real life problem which fits best to their interest.  |
| **Relationships – differences in comparison to other courses already present in the catalogue (if any)** | This course covers the science, technology, and state-of-the-art in multi-scale systems consist of different length scales. Through this course students will learn how to implement scaling laws to engineering systems that they have in other courses and how to combine multi-scale systems consist of different length scales (nano-, micro-, or macro-scales). Through lectures and hands-on projects, participants will learn how scaling effects in nature and biology can be mimicked in engineering applications as a new technology. Bridging multiple courses. |
| **Other Notes** | This course will not have an exam or project, **the course grade will be calculated based on averaging 6 random quizzes during the classes and homework grades.****Average of 6 random quizzes: %60****Average of 4 homework: %40** The backup quiz can be only once, it needs to be officially approved.During the course, each student will make a presentation related to course content. Course grading might change due to pandemic conditions.Weekly topics of the course:

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| **Weeks** | **5 October** | **Course Starts** | **Homework** |
|  | 5-9 October | Scaling in Natural Sciences |  |
| 1 | 12-16 October | Scaling in Mechanical Engineering |  |
| 2 | 19-23 October | Cantilevers and microscopes | HW#1 |
| 3 | 26-30 October | Student presentations |  |
| 4 | 2-6 November | Scaling in Electrostatics |  |
| 5 | 9-13 November | Capacitors |  |
| 6 | 16-20 November | Surface forces | HW#2 |
| 7 | 23-27 November | Student presentations |  |
| 8 | 30-4 December | Scaling in Electromagnetics |  |
| 9 | 7-11 December | Electromagnetic spectrum and sensors  |  |
| 10 | 14-18 December | Working principle of MR | HW#3 |
| 11 | 21-25 December | Student presentations |  |
| 12 | 28-1 December | Scaling in Optics |  |
| 13 | 4-8 January | Microscopes and telescopes | HW#4 |
| 14 | 11-15 January | Student presentations |  |
| **15** | **18-22 January** | **Exams** |  |

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