

**Department of Biomedical Engineering**  
**BME 698-101: Principles of Neuromuscular Engineering**  
**Fall 2006**

**Course Syllabus**

**INSTRUCTOR**

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**CLASS HOURS**

Lecture                      Thursday 6:00pm – 9:05pm                      EAST 636

**OFFICE HOURS (EAST 616)**

Thursday 10:00am– 11:00am, 4:30pm - 5:30pm, other times by appointment.

**READING MATERIAL:**

- Printouts, Powerpoint presentations and research papers will be posted on <http://webct.njit.edu> and will be distributed in the classroom and by email.
- Mark Latash. Neurophysiological Basis of Movement. Human Kinetics, 1998
- Matlab manuals are available online. An excellent Matlab manual is available in the NJIT bookstore: Mastering MATLAB 7 by D. Hanselman and B. Littlefield.

**COURSE OUTLINE**

Recently, it has been shown for the first time that adult brain can be changed through intensive sensorimotor stimulation. In the nearest future, robotics- and virtual reality-based therapies will be designed that will be able to induce restoration of lost function in a damaged brain. Chronically-implanted electrodes will allow people with paralyzed or prosthetic limbs to control them with the force of their mind. These ongoing technological advances, as well as breakthroughs in neuroscience create unprecedented opportunities for a biomedical engineer to revolutionize neuromuscular rehabilitation. Moreover, new technologies will provide for a better understanding of how the brain controls movement and how movement diseases disrupt these control processes. This, in turn, will accelerate the progress in creating rehabilitative therapies. To be successful in this exciting emerging field, an engineer needs an in-depth knowledge of the human motor system. This course will blend neurophysiology, motor control and robotics to get some understanding of the human motor system, with the emphasis on sensorimotor learning and acquisition of new motor skills. We will start with an introduction to the central nervous system. In the first part of the course, we will also study muscle properties, spinal motor circuitry and dynamics of limb motion. This will allow us to understand some basic properties of the machinery that the brain has to control to produce a movement. We will also discuss the principles of sensorimotor learning and neural plasticity. We will then focus on the neuromuscular control of arm movements like

reaching, grasping or balancing a stick. Our objective will be to learn how to relate the motor control problems with the neurophysiology of the motor system and to understand how motor disorders affect movement control. The students will be required to use Matlab and Simulink in their simulations. They will also learn how to use Matlab for movement data analysis. This course is complementary with BME courses 671 - Biomechanics of Human Structure and Motion, 661 - Neural Engineering, and 673 – Biorobotics.

- 09/7 Lecture 1. Review of recent advances in neuromuscular engineering: brain-machine interfaces, transcranial brain stimulation, brain imaging, brain and muscle implants. Introduction to the central nervous system.
- 09/14 Lecture 2. Skeletal muscle, motor unit and electromyography.
- 09/21 Lecture 3. Muscle receptors and spinal reflexes.
- 09/28 Lecture 4. Brain and spinal cord. Functional organization of perception and movement.
- 10/5 Lecture 5. Control of voluntary movement of a single muscle. Mathematical muscle models.
- 10/12 Lecture 6. Control of voluntary movement. Primary and secondary motor areas.
- 10/19 Lecture 7. Sensorimotor brain maps. Brain plasticity and neurorehabilitation.
- 10/26 Lecture 8. Sensorimotor learning. Novel approaches in neurorehabilitation.
- 11/02 Lecture 9. Movement analysis: Registration methods, data processing, hypotheses testing and statistics.
- 11/09 Lecture 10. Paper presentations and discussions.
- 11/16 Lecture 11. Paper presentations and discussions.
- 11/30 Lecture 12. Review lecture.
- 12/07 Lecture 13. Kinematic analysis of a simple motor task (stick balancing). Simulink-based modeling. Final Report is due.

Students will be consulted on any modifications to the syllabus during the semester.

**GRADING:**

Paper Presentation: 45%, Final Report: 45%, Class Participation: 10 %.

**NJIT HONOR CODE**

The NJIT Honor Code will be upheld in this and all courses, and any violation will be brought to the immediate attention of the Dean of Students. The Honor Code can be found at <http://www.njit.edu/academics/honorcode.php>.

**OUTCOMES:**

Students will:

- Obtain basic knowledge of the neurophysiology of human movement and functional organization of the central nervous system.
- Understand the concepts of neuromotor control from an engineering perspective.
- Learn basics of experimental data analysis in Matlab and basic modeling techniques through the use of Simulink.
- Gain the ability to read and understand scientific literature.