



Jordan University of Science and Technology  
Faculty of Engineering  
Biomedical Engineering Department

**BME 562 Control and Communication in the Nervous System**

**Course Catalog**

3 Credit hours (3 h lectures). An introduction to the structural and functional elements common to nervous systems with emphasis on cellular dynamics, interneuronal communication, sensory and effector system.

**Text Book(s)**

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| <b>Title</b>     | Principles of Neural Science                |
| <b>Author(s)</b> | Kandel, E.R., Schwartz, J.H., Jessell, T.M. |
| <b>Publisher</b> | McGraw-Hill                                 |
| <b>Year</b>      | 2000  |
| <b>Edition</b>   | 4 <sup>th</sup> Edition                     |

**References**

|                       |  |
|-----------------------|--|
| <b>Books</b>          | Webster, D.B. (1998) "Neuroscience of Communication." 2 <sup>nd</sup> Edition. Singular.<br>Katz, P.S. (1999) "Beyond Neurotransmission: Neuromodulation and Its Importance for Information Processing." Oxford University Press.<br>Bear, M.F., Connors, B., Paradiso, M. (2006). "Neuroscience: Exploring the Brain." 3 <sup>rd</sup> Edition. Lippincott Williams & Wilkins.<br>Squire, L.R., Roberts, J.L., Spitzer, N.C., Zigmond, M.J. (2002) "Fundamental Neuroscience." 2 <sup>nd</sup> Edition, Academic Press. |
| <b>Journals</b>       | <ul style="list-style-type: none"><li>- The Journal of Neuroscience</li><li>- European Journal of Neuroscience</li><li>- Annual Reviews of Neuroscience</li><li>- Journal of Neurophysiology</li></ul>   |
| <b>Internet links</b> | <ul style="list-style-type: none"><li>- <a href="http://www.bmcentral.com/publications/">http://www.bmcentral.com/publications/</a></li><li>- <a href="http://www.sciencedirect.com">http://www.sciencedirect.com</a></li><li>- <a href="http://www.elsevier.com">http://www.elsevier.com</a></li><li>- <a href="http://www.springer.com">http://www.springer.com</a></li></ul>  |

| <b>Prerequisites</b>           |   |
|--------------------------------|---|
| <b>Prerequisites by topic</b>  | Statistics for Biomedical Engineers, Physiology |
| <b>Prerequisites by course</b> | BME 302, MED 236A                               |
| <b>Co-requisites by course</b> | N/A   |
| <b>Prerequisite for</b>        | None  |

| <b>Objectives and Outcomes<sup>1</sup></b>  |  |
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| <b>Objectives</b>   | <b>Outcomes</b>  |
| 1. Appreciate the role of control and communication in the nervous system in Biomedical Engineering [f,h,j] | 1.1. Appreciate the role of control and communication in the nervous system in the field of biomedical engineering. [f,h,i,j].   |
| 2. Study the relationship between brain and behavior [a,e,g]  | 2.1. Learn the relationship between brain and behavior [g]<br>2.2. Differentiate between distinct functional regions of the brain [a]<br>2.3. Identify the loci of cognitive functions, and their mental representation. [a,e]   |
| 3. Study the classes, structure, and organization of nerve cells [a,c,e,i,g,j,k]                            | 3.1. Differentiate between classes of cells within the nervous system [a,e]<br>3.2. Explain the mechanism of signaling networks, their organization, and their ability for conveying unique information [a]  |
| 4. Analyze the origin of signals and signaling capability in the nervous system [a,e,g,j,k]                 | 4.1. Identify the types ion channels and signaling, the characteristics and structure of ion channels, the origin of membrane potential. [a,e,g,j,k]<br>4.2. Calculate the balance of ion fluxes, the contribution of different ions to this balance, and construct an electrical equivalent circuit. [a,e,g,j,k]  |
| 5. Study local signaling in the nervous system [a,c,e,g,j,k]  | 5.1. Define Local signaling and its relation to passive electrical properties of neurons. [a,e,g,j,k]<br>5.2. Calculate membrane input resistance and membrane capacitance [a,e,g,j,k]<br>5.3. Calculate the efficiency of signal conduction, and velocity of propagation [a,e,g,j,k]  |
| 6. Study propagated signaling and interneuronal / neuromuscular synaptic transmission [a,c,e,g,j,k]         | 6.1. Explain propagated signaling [a,j,k]<br>6.2. Analyze synaptic transmission, chemical vs. electrical synapses, signaling time and signal amplification [a,c,e,g,j,k]<br>6.3. Determine the quantal units involved in transmitter release [a,c,e,g,j,k]<br>6.4. Address signaling at the neuron – muscle synapse, neuromuscular junction and end plate potentials, Patch clamp and single channel currents, ACh gated channels, and synaptic integration. [a,c,e,g,j,k]<br>6.5. Analyze Glutamate, GABA, and Glycine mediated channels, as well as the integration of excitatory and inhibitory signals by these channels. [a,c,e,g,j,k]<br>6.6. Group synapses according to function [a,c,e,g,j,k] |
| 7. Correlate the coding of sensory information to stimulus energy, modality, and                            | 7.1. Explain the coding of sensory information [a]<br>7.2. Correlate stimulus with sensation in the nervous system. [a]<br>7.3. Differentiate between the stimulus energy and sensory modality [a]   |

<sup>1</sup> Lower-case letters in brackets refer to the Program outcomes

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| spatial & temporal distribution. [a,c,e]  | 7.4. Analyze the spatial distribution of sensory neurons, stimulus amplitude and intensity of sensation, as well as the adaptation rate and duration of stimulation [a,e,g,k]   |
| 8. Apply neuro-communication principles to the construction and perception of visual images[a,e]        | 8.1 Explain the mechanism of visual image construction, visual perception, processing of motion, depth, form, and color, as well as visual attention, conscious awareness, and visual processing. [a,e,g,j,k]<br>8.2 Discuss the operation of the eye's receptor sheet, phototransduction, receptor adaptation to changes in light intensity, and retinal output and signal relay [a,e] |
| 9. Encourage life long learning, foster teamwork and enhance students' communication skills [d,g,h,i,k] | 9.1 Write technical report and give oral presentation on team work projects [g,h,i,k]   |

| <b>Topics Covered</b>                       |   |                   |
|---|---|-------------------|
| <b>Week</b>                                 | <b>Topics</b>   | <b>References</b> |
| 1-2   | <ul style="list-style-type: none"> <li>- Relationship between brain and behavior.</li> <li>- Distinct functional regions of the brain.</li> <li>- Localization of cognitive functions.</li> <li>- Representation of mental processes.</li> </ul>  | Chapter 1         |
| 3   | <ul style="list-style-type: none"> <li>- Classes of cells within the nervous system.</li> <li>- Signaling networks and their organization.</li> <li>- Conveying unique information.</li> </ul>  | Chapter 2         |
| 4-5   | <ul style="list-style-type: none"> <li>- Ion channels and signaling</li> <li>- Characteristics and structure of ion channels.</li> <li>- Origin and determination of membrane potential.</li> <li>- Balance of ion fluxes.</li> <li>- Contribution of different ions.</li> <li>- Electrical equivalent circuit.</li> </ul>  | Chapter 6-7       |
| 6   | <ul style="list-style-type: none"> <li>- Local signaling: Passive electrical properties of neurons.</li> <li>- Membrane input resistance.</li> <li>- Membrane capacitance.</li> <li>- Efficiency of signal conduction, and velocity of propagation.</li> </ul>  | Chapter 8         |
| <b>First Exam 11<sup>th</sup> Nov. 2006</b> |   |                   |
| 7   | <ul style="list-style-type: none"> <li>- Propagated signaling</li> <li>- The action potential.</li> <li>- Properties of voltage-gated channels and signaling capabilities.</li> <li>- Signaling function and molecular structure.</li> </ul>  | Chapter 9         |
| 8-9   | <ul style="list-style-type: none"> <li>- Synaptic Transmission.</li> <li>- Chemical vs. electrical synapses.</li> <li>- Signaling time and signal amplification.</li> <li>- Transmitter release.</li> <li>- Quantal units.</li> <li>- Synaptic vesicles and mechanisms regulating their production and release.</li> </ul>  | Chapter 10, 14    |
| 10-11                                       | <ul style="list-style-type: none"> <li>- Signaling at the neuron – muscle synapse</li> <li>- Neuromuscular junction and end plate potentials.</li> <li>- Patch clamp and single channel currents.</li> <li>- ACh gated channels.</li> <li>- Synaptic integration.</li> <li>- Glutamate, GABA, and Glycine mediated channels.</li> <li>- Integration of excitatory and inhibitory signals.</li> <li>- Grouping of synapses according to function.</li> </ul> | Chapter 11, 12    |
| <b>Second Exam 7<sup>th</sup> Dec. 2006</b> |   |                   |
| 12-13                                       | <ul style="list-style-type: none"> <li>- Coding of sensory information.</li> <li>- Correlating stimulus with sensation.</li> <li>- Stimulus energy and sensory modality.</li> <li>- Spatial distribution of sensory neurons.</li> <li>- Stimulus amplitude and intensity of sensation.</li> <li>- Adaptation rate and duration of stimulation.</li> </ul>   | Chapter 21        |
| 14-16                                       | <ul style="list-style-type: none"> <li>- Construction of visual images.</li> <li>- Visual perception.</li> <li>- Processing of motion, depth, form, and color.</li> <li>- Visual attention and conscious awareness.</li> <li>- Visual Processing.</li> <li>- Eye's receptor sheet.</li> <li>- Phototransduction.</li> <li>- Receptor adaptation to changes in light intensity.</li> <li>- Retinal output and signal relay.</li> </ul>                       | Chapter 25, 26    |
| <b>Final Exam</b>                           |   |                   |

| <b>Evaluation</b>         |  |               |
|---------------------------|--|---------------|
| <b>Assessment Tool</b>    | <b>Expected Due Date</b>                               | <b>Weight</b> |
| Participation and project | End of the Semester                                    | 10%           |
| First Exam                | According to the Department schedule                   | 25 %          |
| Second Exam               | According to the Department schedule                   | 25 %          |
| Final Exam                | According to the University final examination schedule | 40 %          |

| <b>Teaching &amp; Learning Methods</b>  |
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| <ul style="list-style-type: none"> <li>- Active learning, where students should be active and involved in the learning process inside the classroom, will be emphasized in the delivery of this course.</li> <li>- Different active learning methods/approaches such as: Engaged Learning, Project-Based Learning, Cooperative Learning, Problem-based Learning, Structured Problem-solving, will be used.</li> <li>- The teaching method that will be used in this course will be composed of a series of mini lectures interrupted with frequent discussions and brainstorming exercises. PowerPoint presentations will be prepared for the course materials.</li> <li>- A typical lecture would start with a short review (~ 5 minutes) using both PowerPoint presentations and the blackboard. This review will also depend on discussions which will gauge the students' digestion of the previous material. Then, the students would have a lecture on new materials using PowerPoint presentations and blackboard. The lecture presentation will be paused every 15 – 20 minutes with brainstorming questions and discussions that will allow the students to reflect and think in more depth about what they learned in that presentation. Then, some example problems will be presented and discussed with the students to illustrate the appropriate problem solving skills that the students should learn. The lecture will be continued for another 15 – 20 minutes, followed by examples and/or a quiz covering the materials taught in the previous two weeks.</li> </ul> |

| <b>Policy</b>          |  |
|------------------------|--|
| <b>Attendance</b>      | Attendance will be checked at the beginning of each class. University regulations will be strictly followed for students exceeding the maximum number of absences. In addition, 0.5 point will be deducted from the grade of homework for each unexcused absence.  |
| <b>Term Project</b>    | Term projects will be conducted by a group of 2-3 students. The team should share and distribute responsibility. The group will submit a professional report and make an oral presentation. Making use of all resources, e.g., patents, journal publications, internet, labs, etc., is encouraged. The report must be typed. Hand-written reports are not accepted. The report should not exceed 10 pages. Late Reports will be penalized. |
| <b>Student Conduct</b> | It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Cheating will not be tolerated in this course. University regulations will be pursued and enforced on any cheating student.                                       |

| <b>Contribution of Course to Meeting the Professional Component</b>   |
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| The course aims at introducing the concepts and physiology of inter-neuronal signaling and communication as it pertains to control and communication in the nervous system. |

| <b>ABET Category Content</b> |             |
|------------------------------|-------------|
| <b>Engineering Science</b>   | 3.0 Credits |
| <b>Engineering Design</b>    |             |

Principles of Neural Science is not difficult to read. Any student with a few elementary sciences courses behind them will be able to understand all of what is put forth in this great work. Diagrams are beautifully unstylized and two-dimensional. The layout of this text is spacious, providing the reader with room to absorb the often-heavy concepts within its pages.