

Course Outline: Biomechatronic Systems
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Course Description
This course will cover the interdisciplinary elements of biomechatronics and provides insight into the diverse applications of current biomechatronics technologies. Most lectures incorporate examples of emerging research and development activities across the medical and engineering fields.

Course Evaluation
Mid-Term Exam: 30%
Project: 30%
Final Exam: 40%

Lectures

Week 1: Introduction to Biomechatronics
- Bio-mechanics, Bio-electrics, Bionics, and Bio-mechatronics
- Physiological and Bio-mechanical Systems
- The Human Factors: Stimulus, Sensing, and Actuation
- Nervous System
- Musculoskeletal System
- Safety and Ethical Aspects

Week 2: Signal Processing
- Biomedical and Bioelectric Signals
- Signal Acquisition
- Amplifiers and Noise
- Time Domain Analysis
- Frequency Domain Analysis
- Practical Considerations

Weeks 3-4: Sensors and Actuators
- Simple Sensors: Switches, Resistive, Capacitive, Inductive, Magnetic
- Sonar and Optical Sensors
- Inertial Measurement Units
- Temperature, Pressure, and Tactile Sensing
- Body-Surface Biopotential Electrodes
- Simple Actuators: Solenoids, DC Motors, Stepper Motors, Servo Motors
- Linear Actuators
- Pneumatic Muscles
- Shape Memory Alloys

Weeks 5-6: Feedback and Control Systems
- Biological Feedback Mechanisms
– Biomechatronic Feedback Mechanisms
– Proportional and Higher-Order Controllers
– System Representation
– Analyzing Complex Models
– System Stability

Weeks 7: Hearing Aids
– Introduction: Hearing Aids and Implants
– Hearing Loss and Diagnosis
– Hearing Aid Technologies
– Bone Conduction Devices
– Middle Ear Implants
– Auditory Brainstem Implants
– Current Research Activities

Weeks 8: Sensory Substitution and Visual Protheses
– Anatomy and Physiology of the Visual Pathway
– Main Causes of Blindness
– Optical Prosthetics: Glasses, Thermal Imagers, Night Vision
– Sonar-Based Systems: Sonar-Based and Laser-Based Systems
– Sensory Substitution: Auditory, Electrotactile, and Vibrotactile Substitution
– Visual Neuroprostheses and Implants
– Current Research Activities

Weeks 9-10: Active Prosthetic Limbs
– A Brief History of Prosthetics
– Active Rehabilitation
– Structure of the Arm and Kinematic Models
– Structure of the Leg and Kinematic Models
– Actuation and Control of Upper Limb Prostheses
– Actuation and Control of Lower Limb Prostheses
– Current Research and Applications

Weeks 11-12: Case Studies and Design Considerations
– Wearable Exoskeletal Rehabilitation
– Closed-Loop Deep Brain Stimulation
– Motion Capture Systems for Therapy Optimization
– Virtual and Augmented Reality in Biomechatronics
– Mathematical Models and Biomechatronics design

References