NEW COURSE PROPOSAL
Graduate Programs

FLORIDA ATLANTIC UNIVERSITY

UGPC Approval	
UFS Approval	
SCNS Submittal	
Confirmed	
Banner	
Catalog	

Department Biomedical Engineering

College Engineering and Computer Science

(*To obtain a course number, contact* ***erudolph@fau.edu***)

Prefix BME **Number** 6275	*(L = Lab Course; C = Combined Lecture/Lab; add if appropriate)* **Lab Code**	**Type of Course** Lecture	**Course Title** Advanced Biorobotics

Credits *(See Definition of a Credit Hour)*

3

Effective Date *(TERM & YEAR)*

Fall 2025

Grading *(Select One Option)*

Regular ◉

Sat/UnSat ○

Course Description *(Syllabus must be attached; see Template and Guidelines)*

The Advanced Biorobotics course explores the exciting field where biology meets robotics. Students will learn how biological systems inspire the creation of innovative robotic technologies that mimic natural movements and functions. The course covers key topics including robot design, motion analysis, sensor technology, and simulation tools. Through lectures, hands-on labs, and projects, students will design and build robots that are inspired by biological systems. This course equips students with the skills to advance in robotics and bioengineering, using nature's designs to solve technical challenges in creative and efficient ways

Prerequisites

EGN 1111C
EGN 3321
EML 4800

Prerequisites, Corequisites and Registration Controls are enforced for all sections of course.

Academic Service Learning (ASL) course ☐

Academic Service Learning statement must be indicated in syllabus and approval attached to this form.

Corequisites

NA.

Registration Controls *(For example, Major, College, Level)*

BME, COECS, Graduate

Minimum qualifications needed to teach course:

Member of the FAU graduate faculty and has a terminal degree in the subject area (or a closely related field).

List textbook information in syllabus or here

1. "Sensors for Mechatronics" by Paul P.L. Regtien
2. "Handbook of Modern Sensors: Physics, Designs, and Applications" by Jacob Fraden (4th Edition)

Faculty Contact/Email/Phone

Prof. Maohua Lin/mlin2014@fau.edu

List/Attach comments from departments affected by new course

There is no other course affected.

Approved by		***Date***
Department Chair	Javad Hashemi	3/10/25
College Curriculum Chair	Francisco Presuel-Moreno	3/11/2025
College Dean	Raquel Assis	3/11/2025
UGPC Chair		
UGC Chair		
Graduate College Dean		
UFS President		
Provost		

Email this form and syllabus to UGPC@fau.edu 10 days before the UGPC meeting.

Department of Biomedical Engineering, Florida Atlantic University Course Syllabus

1. Course title/number, number of credit hours	
Advanced Biorobotics BME 6275	3 credit hours

2. Instructional Method

Include a brief statement about the Instructional Method that is applicable to your class and the expectations for student attendance.

This class will be conducted in class only and there is no remote option.

Examples:

1. *This class will be conducted in class only and there is no remote option.*
2. *This class will be conducted in class and also recorded so students can watch the lectures at a later time and date.*
3. *This class is designated as a "Fully Online Class" with no on-campus attendance requirements.*

Definition of a Credit Hour Policy

The Provost's guidelines regarding the definition of a credit-hour policy can be found at https://www.fau.edu/provost/documents/definition-of-a-credit-hour-september-30-2022.pdf

Each credit hour covers no less than one hour (50 Minutes) of direct instruction each week for fifteen weeks per semester, and covers no less than two hours of out-of-class assignments each week for fifteen weeks per semester, or adjusted equivalent for other delivery modes. Out-of-class assignments may include readings, research, homework assignments, research papers, interactive tutorials, study groups, or other activities appropriate for the course. Courses meeting during shorter enrollment periods must document the equivalent direct instruction time. Online and hybrid courses, laboratory courses, internships, clinical practice, fieldwork, studio work, and other academic work leading to the award of credit must document weekly equivalent instructional activities to demonstrate the effort needed to achieve the course learning outcomes. Additional information on determining equivalent instructional time based on activities can be found at https://www.fau.edu/elearning/faculty/instructional-activity-equivalents/index.php

3. Course pre-requisites, co-requisites, and where the course fits in the program of study

List Prerequisites, Co-requisites:

Mechanical Systems Design (SolidWorks)

Dynamics/ Intro Robotics

EGN 1111C
EGN 3321
EML 4800
If students have not completed the required prerequisites for the course and do not inform their course instructor and advisor, they will be dropped from the course. If this occurs after the first week of the semester, they will be fee liable to the University.

4. Course logistics

Term:

Time & Location:
Lectures:
Labs:

5. Instructor contact information

Instructor's name : Maohua Lin
Office address :
Office Hours:
Contact telephone number:
Email address: mlin2014@fau.edu

6. TA contact information

TA's name *Office address* *Office Hours* *Contact telephone number* *Email address*	

7. Course description

The Advanced Biorobotics course explores the exciting field where biology meets robotics. Students will learn how biological systems inspire the creation of innovative robotic technologies that mimic natural movements and functions. The course covers key topics including robot design, motion analysis, sensor technology, and simulation tools. Through lectures, hands-on labs, and projects, students will design and build robots that are inspired by biological systems. This course equips students with the skills to advance in robotics and bioengineering, using nature's designs to solve technical challenges in creative and efficient ways.

8. Course objectives/student learning outcomes/program outcomes

Course objectives	The objectives of this course are designed to provide students with a deep understanding of biorobotics, focusing on the integration of biological principles into robotics design and function. By the end of the course, students will: 1. **Understand the principles of biorobotics**: Grasp how biological systems inspire the design and functionality of robotic systems, enhancing their adaptability and efficiency. 2. **Analyze biomechanical systems**: Develop the ability to model and analyze the mechanical aspects of biological systems and apply these insights to robotic designs.

	3. **Design and fabricate bio-inspired robots**: Gain hands-on experience in designing, building, and testing robots that mimic biological mechanisms. 4. **Develop computational models for simulations**: Utilize advanced software tools to create and analyze computational models, predicting the behavior and optimizing the design of bio-inspired robots. 5. **Integrate advanced sensors and actuators**: Learn to incorporate sensor and actuator technologies to enhance the perception and interaction of robots with their environments. 6. **Collaborate on interdisciplinary projects**: Work in teams to tackle complex problems, integrating concepts from engineering, biology, and robotics to develop innovative solutions.
Student learning outcomes & relationship to ABET 1-7 objectives	Upon successful completion of this course, students will be able to: 1. **Apply biorobotic principles in design**: Use the understanding of biological systems to innovate and improve robotic applications, enhancing their functionality and efficiency in diverse environments. 2. **Conduct biomechanical analyses**: Perform detailed analyses of biomechanical systems using both theoretical and computational methods to inform the design of robotic systems. 3. **Create and test bio-inspired robots**: Design, fabricate, and evaluate robots that mimic biological forms and functions, demonstrating proficiency in various fabrication techniques and tools. 4. **Utilize simulation software effectively**: Demonstrate proficiency in using simulation software such as ANSYS, SolidWorks, and other relevant tools to model, simulate, and optimize robotic designs. 5. **Integrate sensors and actuators**: Develop the capability to integrate various sensors and actuators into robotic systems, enhancing their autonomous capabilities and interaction with the physical world. 6. **Demonstrate project management skills**: Show effective communication, teamwork, and project management skills by planning, executing, and presenting a group project that addresses a real-world problem using biorobotics.

9. Course evaluation method

- **Homework Assignments (10%):** 5 sets, focusing on design challenges and problem-solving.
- **Research Papers Review (10%):** Students will critically review key publications to understand the current landscape and research trends in biorobotics.
- **Midterm Exam (20%):** Covers all material from the first half of the semester.
- **Project (30%):** A semester-long group project to design and prototype a bio-inspired robot. Design and prototype a bio-inspired robot, focusing on sensor integration and joint functionality. This includes a comprehensive project on designing a spine model using principles learned from the provided studies on spinal biomechanics.
- **Final Exam (30%):** Comprehensive assessment covering the entire course content.

10. Course grading scale

Grading Scale:

A 95-100	A- 90-95	B+ 87.5-90	B 82.5-87.5	B- 80-82.5	
C+ 77.5-80	**C 72.5-77.5**	C- 70-72.5	D+ 67.5-70	D 62.5-67.5	D- 60-62.5
F <60					

11. Policy on makeup tests, late work, and incompletes

Makeup tests are given only if there is solid evidence of a medical or otherwise serious emergency before the tests that prevented the student of participating in the exam. Makeup exams should be administered and proctored by department personnel unless there are other pre-approved arrangements.

***Late work* without verifiable justification will NOT be graded.**

Incomplete grades are against the policy of the department. Unless there is solid evidence of medical or otherwise serious emergency situation incomplete grades will not be given.

12. Special course requirements

1. All students are required to **attend and sign** in for each class. Each student is allowed to have two absences, then one point toward the **FINAL score (1%)** will be deducted for **each** additional absence.
2. When **practices** are assigned after the lecture section, students must finish the exercises and report to the instructor to get the check.
3. You have to finish practice/homework/quiz/test **SOLO**.
4. Both the hardcopy and files in J: will be collected **BEFORE** class begins on the **due** date. **Time Stamp** is required if you submit homework into instructor's mailbox. NO late submission is accepted.
5. A **written proof** is required for a special situation for an absence or a late homework submission, and it must be presented to the instructor **within one week BEFORE the event**.

6. Students must report the discrepancies between the **scores** posted in the Blackboard and appearing on homework and test papers **within ONE week** after they are posted. Afterwards, the scores will not be changed.

13. Classroom etiquette policy

University policy requires that in order to enhance and maintain a productive atmosphere for education, personal communication devices, such as cellular phones, are to be turned off in class sessions.

14. Policy on the Recording of Lectures

Students enrolled in this course may record video or audio of class lectures for their own personal educational use. A class lecture is defined as a formal or methodical oral presentation as part of a university course intended to present information or teach students about a particular subject. Recording class activities other than class lectures, including but not limited to student presentations (whether individually or as part of a group), class discussion (except when incidental to and incorporated within a class lecture), labs, clinical presentations such as patient history, academic exercises involving student participation, test or examination administrations, field trips, and private conversations between students in the class or between a student and the lecturer, is prohibited. Recordings may not be used as a substitute for class participation or class attendance and may not be published or shared without the written consent of the faculty member. Failure to adhere to these requirements may constitute a violation of the University's Student Code of Conduct and/or the Code of Academic Integrity.

15. Attendance Policy Statement

Students are expected to attend all of their scheduled University classes and to satisfy all academic objectives as outlined by the instructor. The effect of absences upon grades is determined by the instructor, and the University reserves the right to deal at any time with individual cases of non-attendance. Students are responsible for arranging to make up work missed because of legitimate class absence, such as illness, family emergencies, military obligation, court-imposed legal obligations or participation in University approved activities. Examples of University-approved reasons for absences include participating on an athletic or scholastic team, musical and theatrical performances and debate activities. It is the student's responsibility to give the instructor notice prior to any anticipated absences and within a reasonable amount of time after an unanticipated absence, ordinarily by the next scheduled class meeting. Instructors must allow each student who is absent for a University-approved reason the opportunity to make up work missed without any reduction in the student's final course grade as a direct result of such absence.

16. Disability Policy Statement

In compliance with the Americans with Disabilities Act Amendments Act (ADAAA), students who require reasonable accommodations due to a disability to properly execute coursework must register with Student Accessibility Services (SAS) and follow all SAS procedures. SAS has offices across three of FAU's campuses – Boca Raton, Davie and

Jupiter – however disability services are available for students on all campuses. For more information, please visit the SAS website at *www.fau.edu/sas/*

17. Counseling and Psychological Services Center

Life as a university student can be challenging physically, mentally and emotionally. Students who find stress negatively affecting their ability to achieve academic or personal goals may wish to consider utilizing FAU's Counseling and Psychological Services (CAPS) Center. CAPS provides FAU students a range of services – individual counseling, support meetings, and psychiatric services, to name a few – offered to help improve and maintain emotional well-being. For more information, go to http://www.fau,edu/counseling/

18. Code of Academic Integrity Policy Statement

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty is considered a serious breach of these ethical standards, because it interferes with the university mission to provide a high quality education in which no student enjoys unfair advantage over any other. Academic dishonesty is also destructive of the university community, which is grounded in a system of mutual trust and place high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. See University Regulation 4.001 at www.fau.edu/regulations/chapter4/4.001_Code_of_Academic_Integrity.pdf

Cell phones are not allowed during exams. If cell phones are detected during any exam periods, this will result in a **grade of "zero" on that exam and a note in the student's academic file.**

19. Required texts/reading/Lab kits

Required Materials

- Lab kits (provided): Include sensors, 3D printer (Bambu X1-Carbon, 4 color), Ecoflex-30, Drgonskin-30, microcontrollers, and basic robotic components.
- Desktop: Required for simulation software and programming tasks.

Related books:

Sensor Technologies

1. **"Sensors for Mechatronics" by Paul P.L. Regtien**
    - This book provides a comprehensive overview of the various types of sensors used in mechatronic systems, including details on their operation, performance, and application.
2. **"Handbook of Modern Sensors: Physics, Designs, and Applications" by Jacob Fraden (4th Edition)**
    - This handbook is excellent for understanding the principles behind sensor operation and the integration of sensors into complex systems, which is critical for developing smart robotic systems.

Soft Robotic Hand Fabrication

3. **"Soft Robotics: Transferring Theory to Application" edited by Alexander Verl, Alin Albu-Schäffer, Oliver Brock, and Annika Raatz**
    - This book explores the rapidly growing field of soft robotics, focusing on the materials, design strategies, and fabrication methods necessary to develop soft robotic systems, including hands.
4. **"Bioinspired Devices: Emulating Nature's Assembly and Repair Process" by Eugene C. Goldfield**
    - Provides insights into designing and fabricating biomimetic devices like soft robotic hands that mimic natural movement and function.

Joint Robotics

5. **"Biorobotics" by Barbara Webb and Thomas R. Consi**
    - The first section describes the sensory systems of biorobotic crickets, lobsters, and ants and the visual system of flies. The second section discusses robots with cockroach motor systems and the intriguing question of how the evolution of complex motor abilities could lead to the development of cognitive functions. The final section discusses higher brain function and neural modeling in mammalian and humanoid robots.

Spine Biomechanics and Simulations

6. **"Biomechanics of the Spine: Basic Concepts, Spinal Disorders and Treatments" by Fabio Galbusera and Hans-Joachim Wilke**
    - This comprehensive book covers the fundamental principles of spine biomechanics and includes sections on modeling and simulation, which are essential for designing and testing robotic applications involving the spine.
7. **"Finite Element Simulations with ANSYS Workbench 2021" by Huei-Huang Lee**
    - Specifically useful for students needing a practical guide to performing biomechanical simulations, this book provides step-by-step tutorials on using ANSYS Workbench, a key tool in biomechanical engineering.

20. Supplementary/recommended readings

1. **"Autonomous Robots: From Biological Inspiration to Implementation and Control" by George A. Bekey**
    - Provides insights into autonomous systems and the biological inspirations that drive current robotic designs.
2. **"Amphibionics: Build Your Own Biologically Inspired Reptilian Robot" by Karl Williams**
    - Useful for students interested in hands-on projects, offering practical advice on building bio-inspired robots.
3. **"Robot Building for Beginners" by David Cook**

- An introductory guide to building simple robots, which can help students in the lab component of the course.

Software Manuals and Documentation

- **ANSYS Workbench Tutorial** - Since the course involves significant simulation work, a tutorial manual for ANSYS Workbench can help students learn how to perform finite element analysis on robotic designs.
- **3D Slicer and SolidWorks Student Guide** - As 3D Slicer and SolidWorks are used for designing parts and assemblies in robotics, a comprehensive guide would be beneficial for lab activities.

Supplementary Materials

- Research articles and conference papers (to be provided throughout the course).

21. Course topical outline, including dates for exams/quizzes, papers, completion of reading

Lecture Topics:

Week 1-2: Introduction to Biorobotics and Overview of Biomechanical Systems

- Introduction to course and fundamental concepts of robotics inspired by biological systems.

Week 3-5: Mechanics of Biological Systems (Sensor Technologies and Smart Prosthetics)

- Detailed study of smart hand prostheses, including tactile sensation and control systems based on my publications, "A New Method to Evaluate Pressure Distribution Using a 3D-Printed C2-C3 Cervical Spine Model with an Embedded Sensor Array" and "Feeling the beat: a smart hand."
- Practical lab sessions to design sensor arrays for robotic applications.

Week 6-8: Sensor and Actuator Technologies (Spine Biomechanics and Robotic Modeling)

- Exploration of spine biomechanics utilizing finite element models and sensor arrays to predict intervertebral loads and posture post-surgery, as discussed in publications like "Robotic Replica of a Human Spine Uses Soft Magnetic Sensor Array to Forecast Intervertebral Loads and Posture after Surgery" and "Effect of graded posterior element and ligament removal on annulus stress and segmental stability in lumbar spine stenosis."

Week 9-11: Robotic Design and Prototyping (Robotic Joints: Shoulders, Knees, and Feet)

- Application of biorobotics principles to the development and enhancement of robotic shoulders, knees, and feet.
- Students will engage in a project to design a joint model, considering biomechanical stresses and material properties.

Week 12-14: Control Systems for Bio-inspired Robots (Advanced Fabrication Techniques and Simulation)

- Use of customized 3D printing systems for multi-material printing and multiphysics simulations.
- Hands-on training in using software tools like 3D slicer, Python, and Ansys Workbench.

Week 15: Project Presentations

- Presentation of group projects, focusing on innovative solutions in biorobotics based on course learnings and individual research.

Lab Topics:

Week 1: Lab Orientation and Safety Training

- Introduction to lab equipment and safety protocols.
- Overview of the semester projects and expectations.

Week 2-3: Sensor Technology and Integration

- Experiment with different sensors used in biorobotics.
- Hands-on session on integrating sensors into a robotic hand prototype.

Week 4-5: Spine Model Analysis

- Application of finite element analysis (FEA) tools to simulate spine mechanics.
- Analysis of data from embedded sensor arrays in spine models.

Week 6-7: Joint Robotics

- Design and assembly of robotic joints (shoulders, knees, and feet).
- Testing joint mechanics under load.

Week 8-9: 3D Printing and Rapid Prototyping

- Utilize customized 3D printing techniques for creating multi-material robotic components.
- Workshop on rapid prototyping processes.

Week 10-11: Simulation Software Mastery

- Comprehensive training in 3D slicer, Ansys Workbench and other tools.
- Develop models and simulate real-world applications.

Week 12-13: Project Work Sessions

- Dedicated sessions for group projects.

- Mid-term presentations for feedback and iterative design improvement.

Week 14: Final Project Development

- Final adjustments and troubleshooting of project prototypes.
- Preparation for final presentations.

Week 15: Final Presentations and Demonstrations

- Groups present their projects and demonstrate their functioning prototypes.

Evaluation based on design, functionality, and innovation.