DEPARTMENT: MECHANICAL ENGINEERING

COURSE #: EML 4841, 3 credits
Course Website

COURSE TITLE:
Bio/Robotic Locomotion

TYPE COURSE:
Technical Elective
UG Track Certification area: Dynamic Systems

TERMS OFFERED: Fall / Spring

CATALOG DESCRIPTION:
This course introduces the fundamental concepts for biological and robotic locomotion with limbs. Muscular-skeletal biomechanics for vertebrate and invertebrate animals are briefly reviewed including an overview of the function of muscles. Morphology, gaits, posture, and the effect of scale on legged locomotion are discussed. The history of legged robots is reviewed. Reduced-order dynamic models of walking and running are introduced. Techniques for analyzing the stability of these periodic hybrid-dynamic systems are covered. The course includes the development and analysis of simulation and hardware platforms of locomotion systems.

PREREQUISITES:
EML 3014C, Dynamic Systems II, or permission of the instructor

AREA COORDINATOR: Dr. Jonathan Clark
RESPONSIBLE FACULTY: Dr. Jonathan Clark

INSTRUCTOR OF RECORD: Dr. Jonathan Clark
Building, Office room number AME 208
(850) 645-0132
clarkj@eng.fsu.edu
Office Hours: after class or by appointment

DATE OF PREPARATION: 06/24/2016 (JC)

CLASS SCHEDULE:

Class: Two times weekly for 1 hr. and 15 min.

Lab: No

TEXTBOOKS/REQUIRED MATERIAL:
1. Principles of Animal Locomotion, McNeill, A. R., 2006

References, Additional Resources:
- Feedback Control of Dynamic Bipedal Robot Locomotion, Westervelt, E. R., Grizzle, J. W., Chevallereau, C., Choi, J. H., and Morris, B., 2007
- • Nonlinear Oscillations, Dynamic Systems, and Bifurcations of Vector Fields, Guckenheimer, J. and Holmes, P., 1983

SCIENCE/DESIGN (%): 60% / 40%

CONTRIBUTION TO MEETING THE PROFESSIONAL COMPONENT:
60% engineering science
40% engineering design

COURSE TOPICS:
The topics to be covered includes (not necessarily in the order shown)

1. Introduction to muscular-skeletal dynamics
2. The function of muscles
3. The effects of morphology, gait, and posture
4. Dynamic scaling

ASSESSMENT TOOLS:
Undergraduate:
1. Quizzes (10%)
2. Homework problems (15%)
3. Reading Assessments (25%)
4. Exams (25%)
5. Final Presentation (25%)

5. Formulation of equations of motion 6. Numerical solutions for non-linear ODEs 7. Static and dynamic stability 8. Poincaré maps **Graduate Topics:** 1. Critiquing technical papers 2. Professional writing standards 3. SLIP models 4. 2D stability analysis	**Graduate:** 1. Quizzes (10%) 2. Homework problems (15%) 3. Reading Assessments (15%) 4. Exams (25%) 5. Final Paper (35%)

Student Learning Objectives for FSU Curriculum File Syllabus	At the end of the course the student should be able to 1. model the dynamics of animal or robot motion using differential equation based mathematical models 2. synthesize relevant information from the body of technical literature 3. communicate technical findings as a team to the scientific community in a professional manner. 4. design a set of experiments to determine the effect of parameter variation on Be able to give professional quality presentations 5. compute the stability of a linerized return map. 6. write Matlab code to model a dynamic locomotion system. **Graduate Objectives** 1. write a professional quality conference paper 2. develop piecewise linear models of locomotion 3. use linear algebra techniques and root finding algorithms to compute stability of higher dimensional systems
Justification for addition or change	The course is needed to fill out the dynamic systems and robotics track of courses. This class provides the basis for inquiry-driven and model-based study of bio-inspired robotic systems.

Level of computer usage:	None ☐ Elementary ☐ Intermediate ☑ Advanced ☐
Modes of Instruction:	Lecture ☑ Lab ☐ DIS ☐ Discussion ☐ Other ☐
Core Curriculum Course:	Yes ☐ No ☑
Availability to other Majors:	Yes ☑ No ☐

ME COURSE OBJECTIVES* [related to ABET Student Outcomes]	1. To teach numerical methods for analyzing discrete time system stability [1, 5] 2. To use differential equation models for analyzing and designing dynamic systems. [1, 3] 3. To teach the use of Matlab as an engineering tool for dynamic system analysis. [10] 4. To teach professional documentation and presentation skills as an individual and as a group [4, 7] 5. To teach how to use primary literature in research [9] 6. To teach how to set up hypothesis driven experimental tests [2] Numbers refer to Departmental Student Outcomes, e.g. for course object 1, [1, 5] refers to student outcomes 1 and 5. **Graduate Objectives** 7. To teach how to communicate findings in a written, professional manner 8. Develop sagittal plane reduced order dynamical models of locomotion 9. To use matrix techniques to analyze stability for 2D locomotion models
ME COURSE OUTCOMES* [related to ME Course Objective] **= FSU Student Learning**	*(Numbers shown in brackets are links to Course Objectives above) By the end of the course, a student should be able to: 1. model the dynamics of animal or robot motion using differential equation based mathematical models [3] 2. synthesize relevant information from the body of technical literature [5]

Objectives	3. communicate technical findings as a team to the scientific community in a professional manner. [4] 4. design a set of experiments to determine the effect of parameter variation on system behavior. [6] 5. give professional quality presentations [4] 6. compute the stability of a linerized return map. [1] 7. write Matlab code to model a dynamic locomotion system. [2, 3] **Graduate Objectives** 8. write a professional quality conference paper [4,7] 9. develop piecewise linear models of locomotion [3,8] 10. use linear algebra techniques and root finding algorithms to compute stability of higher dimensional systems [3,9] Numbers refer to Course Objectives below, e.g. for course outcome 1, [3] refers to course objective 3.

ASSESSMENT TOOL DETAILS

GRADING/ EVALUATION:

Graduate level Prerequisite(s): Students are assumed to be familiar with topics of dynamic systems and controls.

Students who take the graduate-level credits will be asked to do the following beyond the normal assignments:

- Project: The Graduate students' class project will be closely related to their research work, if possible, and be expected to be at a level commensurate with their experience. Ideally these will serve as a rough draft for a future submission to a robotics conference.
- In addition to the general requirements of the projects, graduate students will be required to turn in a comprehensive review of the research subject and course project along with the compilation of an exhaustive list of both classic and the most recent references about the topic studied.

Grades will be based on the following breakdown of graded work:

Undergraduate:

1. Quizzes (10%)
2. Homework problems (15%)
3. Reading Assessments (25%)
4. Exams (25%)
5. Final Presentation (25%)

Graduate:

1. Quizzes (10%)
2. Homework problems (15%)
3. Reading Assessments (15%)
4. Exams (25%)
5. Final Presentation and Paper (35%)

*Since this course is offered as a 4000 and 5000 level course, the exams and project will be commensurate with the level of the course.

Letter grades will be assigned equivalent to the following:

Undergraduate Grading Scale	
Numerical Score	**Letter Grade**
90 - 100	A
80 - 89	B
70 - 79	C
60 - 69	D
0 - 59	F

Graduate Grading Scale	
Numerical Score	**Letter Grade**
90 - 100	A
85 - 89	B+
80-84	B
75-79	C+
70-74	C
60-69	D
0 - 59	F

Departmental policy is that a grade of C or better is required to pass this course.

College of Engineering Undergraduate Policy:

1. It is the policy of the College not to assign "plus and minus (+/-)" grades for undergraduate engineering courses. http://www.eng.fsu.edu/current/undergraduate/guide.html, see Grading Policies.
2. Students are required to be familiar with Academic Policies and Requirements as outlined in the COE Student Handbook http://www.eng.fsu.edu/current/undergraduate/guide.html page 11

ASSIGNMENTS/RESPONSIBILITIES:

Student Responsibilities

- Participation Attendance
- Homework
- Other Daily Responsibilities
- Projects, including information on group processes
- Tests/Exams

Assessment Tools:

1. In-class problems
2. Group project reports
3. Group presentation
4. Homework
5. Quizzes (Quizzes will not be announced ahead of time)
6. Section tests
7. (For Graduate Students) Writing a technical paper

Examinations:

The date of all tests/exams will be announced in advance.

Final Examination: on the COE exam date see http://www.eng.fsu.edu/current/exam_schedule.html

Instructional Method(s)

The primary instructional method is a traditional in-class lecture. There will also be extensive use of the Blackboard web delivery system for distribution of course assignments and other materials. Course materials available from the textbook publisher may also be used. The use of online instructional techniques will be introduced.

COURSE POLICIES:

Attendance Policy:

First day attendance is mandatory for FSU students, and first week attendance is mandatory for FAMU students. Students not in class during the first day (FSU) or first week (FAMU) are to be dropped from the course.

Excused Absences: Excused absences include documented illness, deaths in the immediate family and other documented crises, call to active military duty or jury duty, religious holy days, and official University activities. These absences will be accommodated in a way that does not arbitrarily penalize students who have a valid excuse Consideration will also be given to students whose dependent children experience serious illness.

Please note that the College of Engineering has a restrictive interpretation of what is considered a valid excuse for an absence. See: http://www.eng.fsu.edu/current/undergraduate/guide.html p. 5. If an absence is to be excused, make sure you check beforehand. In case of excused absence, the instructor will work with you to help you make up for missed time and catch up.

Unexcused Absences: A student having more than four unexcused absences will be dropped from the course and assigned the grade F. No exceptions. Tests and exams missed because of unexcused absence receive the grade 0. No exceptions.

Other projects and activities missed completely receive the grade 0 for those projects or activities. No exceptions.

Other Regulations

Note that the penalties for copying work may result in a failing grade for the course. If you are uncertain, please check with the instructor who assigned the work. Working together is encouraged in this course, but blatant copying is not.

Departmental Policy:

A student may continue in the B.S. in ME degree program unless one or more of the following conditions arise;

a. A grade below C in the second attempt of the same engineering course http://www.eng.fsu.edu/me/resources/pdf/ME_Prerequisite_Policy.pdf

b. More than three (3) repeat attempts in engineering courses.
   http://www.eng.fsu.edu/me/resources/pdf/ME_Excessive_Repeat_Policy.pdf
c. Violation of academic honor code as defined in university bulletin or catalog
d. Use of grade forgiveness (currently available for FAMU students only) in more than two (2) courses.

Make-up Assignments

A make-up examination may be granted to students with a valid excused absence. However, you **must** notify me in advance if your absence involves a planned event or observance of a religious holy day. If an emergency prevents you from attending a scheduled examination, you must notified me at your earliest opportunity. You must obtain a valid excused absence for the emergency to be eligible for a make-up examination. Students with a valid excused absence will not be arbitrarily penalized for missing an assignment.
Students without a valid excused absence are not entitled to a make-up examination. However, certain class assignments may be accepted late, with penalty, without a valid excused absence.

DEPARTMENTAL STUDENT OUTCOMES

The department's student outcomes can be found at
http://www.eng.fsu.edu/about/accreditation/program_outcome.html?ID=215&agency=ABET

Program Outcomes/Student Learning Outcomes

Student learning outcomes for students majoring in engineering may be found at
http://www.eng.fsu.edu/outcomes

Location of Academic Learning Compacts (ALC)

COE: http://www.eng.fsu.edu/about/accreditation/program_outcome.html?ID=217&agency=ALC
FAMU: http://www.famu.edu/index.cfm?Assessment&CurrentALCs#engineering
FSU: http://learningforlife.capd.fsu.edu/smalcs/learningCompact.cfm?smalcId=62534

ACADEMIC HONOR POLICY

Students are expected to uphold the University Student Code of Conduct and/or University Academic Honor Code

The Florida A&M University is committed to academic honesty and its core values which include scholarship, excellence, accountability, integrity, fairness, respect, and ethics. These core values are integrated into its academic honesty policy. Being unaware of the Academic Honesty Policy is not a defense to violations of academic honesty. Academic Honesty Policy violations shall be reported and appropriate actions taken by the Department Chair and Associate Dean for Student Affairs and curriculum. The complete Florida A&M Student Code of Conduct - Regulation 2.012 (8a) can be found on (p. 5) http://www.famu.edu/judicialAffairs/Regulation%202_012%20Student%20Code%20of%20Conduct.pdf and in the Student Handbook "The Fang" p. 61 http://www.famu.edu/Students/STUDENT%20HANDBOOK%20%28FANG%29%202012-2014.Updated%208.22.13.pdf p 61

The Florida State University Academic Honor Policy outlines the University's expectations for the integrity of students' academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process. Students are responsible for reading the Academic Honor Policy and for living up to their pledge to ". . . be honest and truthful and . . . [to] strive for personal and institutional integrity at Florida State University." (Florida State University Academic Honor Policy, found at http://fda.fsu.edu/Academics/Academic-Honor-Policy.)

AMERICANS WITH DISABILITIES ACT

During the first week of class students with disabilities needing academic accommodation should:

1) register with and provide documentation to the FAMU **LDEC** or FSU **SDRC**; and
2) bring a letter to the instructor indicating the need for accommodation and what type.

Please note that instructors are not allowed to provide classroom accommodation to a student until appropriate verification from the Student Disability Resource Center has been provided.

For more information about services available to FAMU students with disabilities, contact **The Learning Development and Evaluation Center (LDEC)**

677 Ardelia Court Florida A&M University Tallahassee, FL 32310 Nathaniel Holmes, Director Donna Shell, Asst. Director	599-3180 (phone) 561-2512 (fax) 561-2783 (TDD) http://www.famu.edu/index.cfm?a=EOP&p=ADA

For more information about services available to FSU students with disabilities, contact the:
Student Disability Resource Center (SDRC)

874 Traditions Way 108 Student Services Building Florida State University Tallahassee, FL 32306-4167	(850) 644-9566 (voice) (850) 644-8504 (TDD) sdrc@admin.fsu.edu http://www.disabilitycenter.fsu.edu/

This syllabus and other class materials are available in alternative format upon request.

UNIVERSITY'S NON-DISCRIMINATION POLICY STATEMENT

FAMU: http://www.famu.edu/index.cfm?EOP&NON-DISCRIMINATIONPOLICYSTATEMENT
FSU: http://www.hr.fsu.edu/PDF/Publications/diversity/EEO_Statement.pdf

SYLLABUS CHANGE POLICY:

Except for changes that substantially affect implementation of the evaluation (grading) statement, this syllabus is a guide for the course and is subject to change with advanced notice.