FAIRMONT STATE UNIVERSITY™

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MEMORANDUM

TO: Faculty Senate

FROM: Susan Ross

DATE: February 17, 2021

SUBJECT: Curriculum Proposal #20-21-12

The Physics Program proposes to add a new course to the course catalog that has previously been offered and taught as Special Topics courses numbered 1099-001, Nonlinear Dynamics and Chaos. This course will be taught as a science elective. The course teaches analytical methods and applications useful to students in Mathematics, Computer Science, Chemistry, Biology and Engineering Technology.

cc: Richard Stephens
Lori Schoonmaker
Stephanie Gabor
Laura Ransom
Siegfried Bleher

CURRICULUM PROPOSAL (Submit one hard copy and an electronic copy to the Associate Provost by the second Tuesday of the month.)

Proposal Number:	#20-21-12
School/Department/Program:	College of Science and Technology/Natural Sciences Department/Physics Program
Preparer/Contact Person:	Siegfried Bleher
Telephone Extension:	X4582
Date Originally Submitted:	September 13, 2019
Revision (Indicate date and label it Revision #1, #2, etc.):	**Revision #1**
Implementation Date Requested:	Fall 2021

I. **PROPOSAL** Write a brief abstract, not exceeding 100 words, which describes the overall content of the proposal.

The Physics Program proposes to add a new course to the course catalog that has previously been offered and taught as Special Topics courses numbered 1099-001, Nonlinear Dynamics and Chaos. This course will be taught as a science elective. The course teaches analytical methods and applications useful to students in Mathematics, Computer Science, Chemistry, Biology and Engineering Technology.

II. **DESCRIPTION OF THE PROPOSAL** Provide a response for each letter, A-H, and for each Roman Numeral 11-**V.** If any section does not apply to your proposal, reply **N/A.**

A. Deletion of course(s) or credit(s) from program(s)

N/A

Total hours deleted. ________________

B. Addition of course(s) or credit(s) from program(s)

NIA

Total hours added. ________________

C. Provision for interchangeable use of course(s) with program(s)

N/A

D. Revision of course content Include, as an appendix, a revised course description, written in complete sentences, suitable for use in the university catalog.

N/A

E. Other changes to existing courses such as changes to title, course number, and elective or required status.

NIA

F. Creation of new course(s). For each new course

1. Designate the course number, title, units of credit, prerequisites (if any), ownership (FSU or shared) and specify its status as an elective or required course. If you are creating a shared course, attach a memo from the Deans of the affected Schools explaining the rationale for the course being shared.

Course Number	Title	Credit	Prerequisites	Ownership	Status
PHYS 2203	Nonlinear Dynamics and Chaos	3	MATH 1586, or MATH 2502, or TECH 3300	FSU	Elective

2. Include, as an appendix, a course description, written in complete sentences, suitable for use in the college catalog.

   Please see Appendix A

3. Include, as an appendix, a detailed course outline consisting of at least two levels.

   Please see Appendix A

4. In order to meet the requirements as outlined in Goal One of the Strategic Plan, please include Outcome Competencies and Methods of Assessment as an appendix. Examples are available upon request from the Chair of the Curriculum Committee.

   Please see Appendix A

G. Attach an itemized summary of the present program(s) affected, if any, and of the proposed change(s).

Describe how this proposal affects the hours needed to complete this program. Specifically, what is the net gain or loss in hours? Use the format for Current and Proposed Programs in Appendix A

NIA

III. RATIONALE FOR THE PROPOSAL

A **Quantitative Assessment:** This course has been taught once in Spring 2017, with four students registered, one withdrew, two As, one B. Each student who completed presented a 20 minute scholarly talk at the end of the semester on a topic of their choice that demonstrated principles and analytical methods of nonlinear dynamics.

B. **Qualitative Assessment:** No new materials are needed for this course, apart from the textbook, a copy of which can be provided to the library. Numerical methods will be implemented through Excel and Excel VBA (Visual Basic for Applications). The primary motivation to offering this course is its interdisciplinary and integrative nature. Students will use methods of analysis (numerical, geometric and analytical) to examine and predict behavior of a selection of problems taken from biology, chemistry, climate dynamics, ecology, and engineering. The extension of principles of dynamical behavior in each of the domains of study listed from equilibrium conditions to non-equilibrium and irreversible conditions will be demonstrated through model equations. Students choose a topic most relevant to their major to apply these models and methods of analysis.

A partial list of references in the course textbook exhibits the range of applicability of the methods of analysis taught in this course:

- Abraham, RH., and Shaw, D. C. (1983) *Dynamics: The Geometry of Behavior. Part* 2: *Chaotic Behavior*
- Abrams, D. M, and Strogatz, S. H. (2003) Modelling the dynamics of language death, Nature 424, 900.
- Argoul, F., et al. (1987) Chemical chaos: From hints to confirmation. Ace.Chem. Res. 20,436.
- Buck, *J.* (1988) Synchronous rhythmic flashing of fireflies II. Quart. Rev. Biol. 63,265.
- Cuomo, K. M., and Oppenheim, AV (1993) Synchronized chaotic circuits and systems for communications. *MIT Research Laboratory of Electronics Technical Report* No. 575.
- Drazin, P. G., and Reid, W. H. (1981) *Hydrodynamic Stability* (Cambridge University Press, Cambridge, England).
- Firth, W. *J.* (1986) Instabilities and chaos in lasers and optical resonators. In AV Holden, ed *Chaos* (Princeton University Press, Princeton, NJ).
- Kermack, W. 0., and McKendrick, AG. (1927) Contributions to the mathematical theory of epidemics -1. *Proc. Roy* Soc. 115A, 700.
- Ludwig, D. Jones, D. D. and Holling, C. S. (1978) Qualitative analysis of insect outbreak systems:A the spruce budworm and forest *J Anim. Ecol.* 47, 315.
- May, R,. M. (1972) Limit cycles in predator-prey communities. *Science* 177, 900.
- Rinaldi, S. et al. (2013) A mathematical model of"Gone with the Wind." *Physica A* 392, 3231.
- Sel'kov, E. E. (1968) Self-oscillations in glycolysis. A simple kinetic model. *Eur. J Biochem.* 4, 79.

IV Should this proposal affect any course or program in another school, a memo must be sent to the Dean of each school impacted and a copy of the memo(s) must be included with this proposal. In addition, the Deans of the affected schools must sign below to indicate their notification of this proposal.

By signing here, you are indicating your college's/school's notification of this proposal.

College/School	Dean	Signature
SciTech	Steven Rouf	Steven Rouf

V. Should this proposal affect any course to be added or deleted from the general studies requirements, a memo from the chair of the General Studies Committee indicating approval of the change must be included with this proposaL

This course does not satisfy the requirements to be included in the list of Core Curriculum courses.

VI. ADDITIONAL COMMENTS.

APPENDIX A - PHYS 2203

Course Description

Students taking this course will apply geometric and numerical methods to predict the qualitative and quantitative behavior of certain natural systems occurring in physics, biology and chemistry, as well as in mechanical and electronic systems that are inherently nonlinear. Although analytic solutions are generally not available for such nonlinear systems, typical features in their evolution, such as bifurcations, chaotic behavior and fractals, will be modeled and studied by students taking this course. The prerequisites for this course are Calculus I and II (MATH 1586, or MATH 2502, or TECH 3300).

Course Outline

- **Dynamics in one dimension**
  - 1D flows
  - 1D bifurcations
  - Flows on a circle
- **Dynamics in two dimensions**
  - 2D flows: linear systems
  - 2D flows: phase plane analysis
  - 2D flows: limit cycles
  - 2D bifurcations
- **Dynamics in three dimensions**
  - Lorenz equations
- **Iterative maps**
  - Logistic map
  - Fractals
- **Strange attractors**
  - Routes to chaos

Outcome Competencies

1. Students will apply geometric (phase space) methods to analyze qualitative behavior of first order and second order linear and nonlinear differential equations that appear in chemistry, physics, biology and engineering. These methods permit qualitative behavior of complex systems to be assessed without explicitly solving the equations.

   Assessment: Weekly homework, midterm exam, final exam

2. Students will use numerical methods to calculate trajectories of nonlinear sets of first order differential equations and compare results with qualitative geometric methods.

   Assessment: Weekly homework, midterm exam, final exam

3. Students will demonstrate and apply geometric and/or numerical phase space methods in the context of a project/ term paper of the student's choice, relevant to their majors.

   Assessment: term paper

Methods of Assessment

1. Weekly homework (25% of course grade)
2. Midterm exam (25% of course grade)
3. Term paper and presentation (25% of course grade)
4. Final exam (25% of course grade)