Submit original with signatures + 1 copy + electronic copy to UAF Governance. See http://www.uaf.edu/uafgov/faculty/cd for a complete description of the rules governing curriculum & course changes.

TRIAL COURSE OR NEW COURSE PROPOSAL

<table>
<thead>
<tr>
<th>SUBMITTED BY:</th>
<th>Department</th>
<th>College/School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physics</td>
<td>CNSM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prepared by</th>
<th>Renate Wackerbauer</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>474-6108</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Email Contact</th>
<th><a href="mailto:ffraw1@uaf.edu">ffraw1@uaf.edu</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty Contact</td>
<td>Renate Wackerbauer</td>
</tr>
</tbody>
</table>

1. ACTION DESIRED (CHECK ONE):
   - Trial Course
   - New Course X

2. COURSE IDENTIFICATION:
   - Dept: PHYS
   - Course #: 648
   - No. of Credits: 3

   Justify upper/lower division status & number of credits:
   - 3 hours of lecture per week for 1 semester; prerequisite is graduate standing

3. PROPOSED COURSE TITLE:
   - Nonlinear Dynamics

4. CROSS LISTED? YES/NO
   - No
   - If yes, Dept.:

5. STACKED? YES/NO
   - No
   - If yes, Dept.:

6. FREQUENCY OF OFFERING:
   - alternate spring

7. SEMESTER & YEAR OF FIRST OFFERING (if approved):
   - spring 2012

8. COURSE FORMAT:
   - COURSE FORMAT (check one):
     - 1
     - 2
     - 3
     - 4
     - 5 X 6 weeks to full semester
   - OTHER FORMAT (specify):
     - Mode of delivery (specify lecture, field trips, labs, etc):
       - 3h lectures per week
### 9. CONTACT HOURS PER WEEK:

<table>
<thead>
<tr>
<th>LECTURE</th>
<th>LAB</th>
<th>PRACTICUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 hours/week</td>
<td>0</td>
<td>0 hours/week</td>
</tr>
</tbody>
</table>

Note: # of credits are based on contact hours. 800 minutes of lecture=1 credit. 2400 minutes of lab in a science course=1 credit. 1600 minutes in non-science labs=1 credit. 2400-4800 minutes of practicum=1 credit. 2400-8000 minutes of internship=1 credit. This must match with the syllabus. See [http://www.uaf.edu/uafgov/faculty/credits.html](http://www.uaf.edu/uafgov/faculty/credits.html) for more information on number of credits.

### 10. COMPLETE CATALOG DESCRIPTION including dept., number, title and credits (50 words or less, if possible):

**PHYS F648 Nonlinear Dynamics**  
3 Credits, Offered alternate spring (even numbered years)

Introduction into the dynamics of nonlinear systems. Continuous and discrete dynamical systems, stability analysis, bifurcations, limit cycle, chaos and strange attractors, fractals and dimension algorithms, controlling chaos, synchronization processes, and stochastic dynamical systems. Prerequisites: Graduate standing or permission of instructor. (3+0)

### 11. COURSE CLASSIFICATIONS:

- **H** = Humanities
- **N** = Natural Science
- **S** = Social Sciences

Will this course be used to fulfill a requirement for the baccalaureate core?  
**YES**  
**NO**

If YES, check which core requirements it could be used to fulfill:

- **O** = Oral Intensive, Format 6
- **W** = Writing Intensive, Format 7
- **Natural Science, Format 8**

### 12. COURSE REPEATABILITY:

Is this course repeatable for credit?  
**YES**  
**X**  
**NO**

Justification: Indicate why the course can be repeated (for example, the course follows a different theme each time).

How many times may the course be repeated for credit?  
TIMES

If the course can be repeated with variable credit, what is the maximum number of credit hours that may be earned for this course?  
CREDITS

### 13. GRADING SYSTEM:

- **LETTER:**  
  - X
- **PASS/FAIL:**

### 14. PREREQUISITES:

- Graduate standing, or permission of instructor
These will be *required* before the student is allowed to enroll in the course.

**RECOMMENDED**

Classes, etc. that student is strongly encouraged to complete prior to this course.

### 15. SPECIAL RESTRICTIONS, CONDITIONS

### 16. PROPOSED COURSE FEES

$0

Has a memo been submitted through your dean to the Provost & VCAS for fee approval?  

Yes/No

### 17. PREVIOUS HISTORY

Has the course been offered as special topics or trial course previously?  

Yes/No

Yes

If yes, give semester, year, course #, etc.:

Spring 2008, Fall 2009 (moved from Spring 2010, since instructor on sabbatical)

### 18. ESTIMATED IMPACT

**WHAT IMPACT, IF ANY, WILL THIS HAVE ON BUDGET, FACILITIES/SPACE, FACULTY, ETC.**

Course exists already as a trial course, no further impact on faculty and budget.

### 19. LIBRARY COLLECTIONS

Have you contacted the library collection development officer (ffklj@uaf.edu, 474-6695) with regard to the adequacy of library/media collections, equipment, and services available for the proposed course?  

If so, give date of contact and resolution.  

If not, explain why not.

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
<th>X</th>
</tr>
</thead>
</table>

contacted library when trial course was approved, July 2008; in addition no special library collection/equipment necessary for this course. Journals "physics today" and "physical review letters" and physical review E and Chaos" are available online; special articles can be ordered (and have been ordered in earlier courses) from GI library.

### 20. IMPACTS ON PROGRAMS/DEPTS

What programs/departments will be affected by this proposed action?  

Include information on the Programs/Departments contacted (e.g., email, memo)

The graduate program of the department of physics is broadened by offering this course, consistent with the goal of the department and approved by the faculty in the department.

### 21. POSITIVE AND NEGATIVE IMPACTS

Please specify positive and negative impacts on other courses, programs and departments resulting from the proposed action.

Nonlinear dynamics is one area of expertise in the physics department, and offering such a course is timely and necessary for students' success in their graduate studies.

Nonlinear dynamics is a newly evolving field that is important for nearly all research areas pursued in the department of physics. Due to its interdisciplinary nature students from other departments have taken this course (mathematics, atmospheric sciences, geosciences, engineering) when offered as a trial course. There are no negative impacts; the department has the "man/women" power to teach this course.
JUSTIFICATION FOR ACTION REQUESTED

The purpose of the department and campus-wide curriculum committees is to scrutinize course change and new course applications to make sure that the quality of UAF education is not lowered as a result of the proposed change. Please address this in your response. This section needs to be self-explanatory. Use as much space as needed to fully justify the proposed course.

Nonlinear dynamics describes systems with interactions, feedback and various couplings and drive. Thus it is at the basics of various physical, biological, chemical and even social sciences.

Offering this course in nonlinear dynamics also fits well with the UAF Center for Complex Systems Studies, to foster interdisciplinary collaborations in the Sciences. This course introduces the basics in nonlinear dynamics (complex systems studies) and therefore contributes to the integration of research and teaching across disciplines at UAF.

APPROVALS:

Date
Signature, Chair, Program/Department of:

Date
Signature, Chair, College/School Curriculum Council for:

Date
Signature, Dean, College/School of:

Date
Signature of Provost (if applicable)

Offerings above the level of approved programs must be approved in advance by the Provost.

ALL SIGNATURES MUST BE OBTAINED PRIOR TO SUBMISSION TO THE GOVERNANCE OFFICE

Date
Signature, Chair, UAF Faculty Senate Curriculum Review Committee

ADDITIONAL SIGNATURES: (If required)

Date
ATTACH COMPLETE SYLLABUS (as part of this application).
Note: syllabus must follow the guidelines discussed in the Faculty Senate Guide: http://www.uaf.edu/uafgov/faculty/cd/syllabus.html.

The department and campus wide curriculum committees will review the syllabus to ensure that each of the items listed below are included. If items are missing or unclear, the proposed course change will be denied.

**Syllabus CHECKLIST for all UAF courses**

During the first week of class, instructors will distribute a course syllabus. Although modifications may be made throughout the semester, this document will contain the following information (as applicable to the discipline):

1. **Course information:**
   - Title, θ number, θ credits, θ prerequisites, θ location, θ meeting time (make sure that contact hours are in line with credits).

2. **Instructor (and if applicable, Teaching Assistant) information:**
   - Name, θ office location, θ office hours, θ telephone, θ email address.

3. **Course readings/materials:**
   - Course textbook title, θ author, θ edition/publisher.
   - Supplementary readings (indicate whether θ required or θ recommended) and any supplies required.

4. **Course description:**
   - Content of the course and how it fits into the broader curriculum;
   - Expected proficiencies required to undertake the course, if applicable.
   - Inclusion of catalog description is strongly recommended, and Description in syllabus must be consistent with catalog course description.

5. θ **Course Goals (general) and θ Student Learning Outcomes (more specific)**

6. **Instructional methods:**
   - Describe the teaching techniques (eg: lecture, case study, small group discussion, private instruction, studio instruction, values clarification, games, journal writing, use of Blackboard, audio/video conferencing, etc.).

7. **Course calendar:**
   - A schedule of class topics and assignments must be included. Be specific so that it is clear that the instructor has thought this through and will not be making it up on the fly (e.g. it is not adequate to say “lab”. Instead, give each lab a title that describes its content). You may call the outline Tentative or Work in Progress to allow for modifications during the semester.

8. **Course policies:**
   - Specify course rules, including your policies on attendance, tardiness, class participation, make-up exams, and plagiarism/academic integrity.

9. **Evaluation:**
   - Specify how students will be evaluated, θ what factors will be included, θ their relative value, and θ how they will be tabulated into grades (on a curve, absolute scores, etc.)

10. **Support Services:**
Describe the student support services such as tutoring (local and/or regional) appropriate for the course.

11. Disabilities Services:
The Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials.

State that you will work with the Office of Disabilities Services (203 WHIT, 474-7043) to provide reasonable accommodation to students with disabilities.
Physics 648 - Nonlinear Dynamics - Fall09

| Instructor          | Renate Wackerbauer,  
|                    | Office Location: NSCI 106  
|                    | phone: 474-6108  
|                    | e-mail: ffrawl1@uaf.edu  
| Open office hours  | Walk-ins are very welcome; appointments help; email is effective for straightforward questions.  
| Course info        | Phys648, 3 credits  
| Prerequisites      | graduate standing or instructor's permission  
| Lectures           | MWF 13:00 to 14:00 pm, NSCI 207. The lectures will explore in depth material presented in the text.  
| Noyes Lab          | Access to the Noyes Computer Lab (Rm 101 NSCI) is provided to all students enrolled in a Physics course. Your polar express card lets you in.  

**Text**

**Required text:**

**Supplementary readings:**

**Course Content**

Tentative course calendar

Introduction into the dynamics of nonlinear systems. Continuous and discrete dynamical systems, stability analysis, bifurcations, limit cycle, chaos and strange attractors, fractals and dimension algorithms, controlling chaos, synchronization processes, and stochastic dynamical systems.
This course provides an introduction into nonlinear dynamics at the graduate level. Dynamical systems that are characterized with coupling and feedback processes often show dynamical or spatiotemporal patterns that need to be described at the systems level; a reductionist approach is not suited for complex systems, since the entire system behaves different to the sum of its part. Complex systems can be high-dimensional but must not. A necessary requirement for complex dynamics is nonlinear equations of motion.

Students learn,
*how to analyze the stability of complex systems
*how nonlinear systems differ from linear systems regarding dynamical properties
*how sensitivity of system dynamics is related to predictability, determinism, and control
*to explore dynamical systems analytically and with computer simulations

Homework assignments
Homework will be assigned weekly and will be due by 5:00 pm on the following Friday, unless explicitly altered at the time of assignment. Late homework will not be accepted. Finished homework should be placed in the designated box in the main office of the Physics Department. Homework assignments and solutions will be posted in the glass case in the Physics Department hallway.
I HIGHLY appreciate it if you RECYCLE paper for your homeworks!

Explore complex system dynamics with a project that includes a computational component! For example a bifurcation analysis of a dynamical system, the calculation of fractal dimensions of certain cracks; nonlinear time series analysis of an ECG, or other biological, financial, physical measurement series; correlations between two time series (synchronization); phase space analysis and quantification. Explore a topic related to this course on your own. The project needs to be based on a published paper or text book, online sources like Wikipedia are not allowed. A list of possible topics is given here: topics. A student can also choose a topic of their interest in agreement with the instructor. All topics should be discussed with the instructor at least 5 days before the topic is due; topics are due on October 7.

**Project paper:** The results of your project should be turned in as paper, like an article in the journal "Physics Today". It should consist of 8-10 pages, including introduction, results and discussion, summary, and about 5 references. An outline of the paper need to be turned in on October 21; the paper is due November 30. The grade is determined from physics (60%) and style (40%) of the paper. The physics part includes correct physics, level covered, how explained, how introduced, understanding, terms defined. The style part includes organization and structure, title, references given, figures referenced, good to read.

**Presentation:** The paper will be presented to the class in a 15minutes talk (excluding discussions) the week before finals. The grade is determined from clarity of presentation (50%) and content (50%). The clarity of presentation includes board/transparency use, clarity of writing/slides, references used, blocking board/screen, speaking clearly and loud, speed of speach, facing class and eye contact, dealing with questions. The content includes appropriate level, enough details, terms introduced before used, correct physics, how explained.
Examinations

<table>
<thead>
<tr>
<th>Exams</th>
<th>Date</th>
<th>Textbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm exam</td>
<td>Friday, October 16</td>
<td>Strogatz, approx chapt 1-7</td>
</tr>
<tr>
<td>Final exam</td>
<td>Wednesday, Dec 16, 1-3pm</td>
<td>Strogatz, approx chapt 1-12</td>
</tr>
</tbody>
</table>

Grading

The maximum score for each homework will be 100 points. A solution (homework, exam) that presents nothing more than a restatement of the problem will receive zero credit. Credit will be given for clarity of presentation, illegible work will not be graded. Grades are assigned as follows: A+ (above 95%), A (above 90%), A- (above 85%), B+ (above 80%), B (above 75%), B- (above 70%), C+ (above 65%), C (above 60%), C- (above 55%), D+ (above 50%), D (above 45%), D- (above 40%), else F.

For the final grade homework, exams, etc. will be weighted as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
</tr>
<tr>
<td>Presentation</td>
<td>20%</td>
</tr>
<tr>
<td>Paper</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm</td>
<td>15%</td>
</tr>
<tr>
<td>Final exam</td>
<td>15%</td>
</tr>
</tbody>
</table>

Course policies

Attendance at lectures is expected. Active class participation, questions, comments on newspaper articles on modern physics are extremely welcome in the lectures. A missed exam will receive 0 credit unless the instructor is notified by email, phone, etc before the exam starts. Make-up exams will be individually scheduled with the student.

Student Obligations

As students of UAF, you are bound by the policies and regulations of the University of Alaska, UAF rules and procedures, and the Student Honor Code. You are obligated to make yourselves familiar with all conditions presented in the UAF Catalog. Plagiarism on homework, or on exam, or on presentation or on paper will result in a failing grade.

Disabilities Services

The Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. If you have any kind of disability, please ensure that you go to the disabilities services program coordinator. I will work with the office of disabilities services (203 WHIT, 474-7043) to provide reasonable accomodations to students with disabilities.
Physics 648: Suggestions for project topics

1. Flow on circle and synchronization of fire flies (Strogatz, chapter 4)
2. Flow on circle and simulations to millennium bridge (Strogatz, chapter 4 and Nature paper)
3. Weakly nonlinear oscillators (start with Strogatz, chapter 7.6)
4. Choose dynamical system, do bifurcation analysis, and plot phase diagrams
5. From quasiperiodicity to chaos
6. Dynamical behavior in a neuron model (for example spiking)
7. The Henon map
8. Phase synchronization and application to simulated data
9. Phase synchronization and application to real data
10. Introduction into time-delay differential equation
11. Nonlinear time series analysis; prediction algorithms
12. Nonlinear time series analysis; recurrence plots
13. Embedding and dimension algorithms; application to real data
14. Embedding and dimension algorithms; application to simulated data
15. Calculation of fractal (and other) dimensions of cracks or other spatial patterns
16. How to calculate Lyapunov exponent(s) from data
17. Spurious Lyapunov exponents
18. The Lyapunov spectrum
19. How to numerically determine stable and unstable manifolds
20. Dynamical systems and noise
21. Chaos and feedback control
22. Chaotic scattering
23. Diffusion-limited aggregation and application
24. Introduction to cellular automata
25. Self-organized criticality and the sandpile model
26. Self-organized criticality and the earthquake model
27. ...
28. ...
29. ... your own project - discuss with me at least 1 week before topic is due -
## Physics 648: Homework Assignments

<table>
<thead>
<tr>
<th>Homework #</th>
<th>Chapter</th>
<th>Problems</th>
<th>Date due</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Strogatz:</td>
<td>2.2.10, 2.3.4, 3.3.2, 3.4.5-3.4.10, 3.4.14, 3.4.16</td>
<td>Friday, Sept 18</td>
</tr>
<tr>
<td>2</td>
<td>Strogatz:</td>
<td>3.5.4 3.6.5, 5.1.10, 5.2.3, 5.2.5, 5.2.7, 5.2.9, 5.2.11, 6.1.1, 6.1.5</td>
<td>Friday, Sept 25</td>
</tr>
<tr>
<td>3</td>
<td>Strogatz:</td>
<td>6.1.10, 6.3.16, 6.5.19, 6.6.2, 7.1.2, 7.2.10, 7.3.3, 7.5.7</td>
<td>Friday, Oct 2</td>
</tr>
<tr>
<td>4</td>
<td>Strogatz:</td>
<td>8.1.6, 8.1.12, 8.2.3, 8.2.8, 8.2.11, 8.4.3, 8.7.3</td>
<td>Friday, Oct 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No HW this week, prepare for exam on Friday</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Strogatz:</td>
<td>9.3.2, 9.3.3, 9.3.4, 9.3.5, 9.3.6, 9.3.7, 9.5.1</td>
<td>Friday, Oct 23</td>
</tr>
<tr>
<td>6</td>
<td>Strogatz:</td>
<td>10.1.11, 10.1.12, 10.1.13, 10.2.4-10.2.8 (pick 2 problems, rest is for fun)</td>
<td>Friday, Oct 30</td>
</tr>
<tr>
<td>7</td>
<td>Strogatz:</td>
<td>10.3.6, 10.4.1, 10.5.1, 10.5.4, 10.5.6 (including orbit diagram)</td>
<td>Friday, Nov 6</td>
</tr>
<tr>
<td>8</td>
<td>Strogatz:</td>
<td>10.6.2, 10.7.1, 10.7.8, 11.3.1</td>
<td>Friday, Nov 13</td>
</tr>
<tr>
<td>9</td>
<td>Strogatz:</td>
<td>11.3.3, 11.3.7, 11.4.2, 11.4.6</td>
<td>Friday, Nov 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No HW this week, paper due on Nov. 30</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Strogatz:</td>
<td>12.1.4, 12.1.8, 12.2.6, 12.2.7</td>
<td>Monday, Dec 7</td>
</tr>
</tbody>
</table>
# Tentative weekly course calendar for Phys648

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topics covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sept 4</td>
<td>Introduction: nonlinear dynamics, complex systems, interdisciplinary science</td>
</tr>
</tbody>
</table>
| 2    | Sept 7-11  | 1-dimensional flows, stability analysis, steady state classification, elementary bifurcations: saddle-node, transcritical  
          | No HW due this week!                                                      |
| 3    | Sept 14-18 | elementary bifurcations: pitchfork  
          | 2-dimensional flows: linear systems, classification, phase space analysis  
          | HW#1 due friday  
          | Sept 18: Last day to drop                                                   |
| 4    | Sept 21-25 | limit cycles, Poincare-Bendixson theorem, excitable systems  
          | HW#2 due friday                                                            |
| 5    | Sept 28-Oct 2 | Bifurcations: elementary bifurcations, sub- (super-) critical Hopf bifurcations, global bifurcations  
          | HW#3 due friday                                                            |
| 6    | Oct 5-9    | Lorenz system, strange attractor, Lyapunov exponent  
          | HW#4 due friday  
          | Project topic due on Wednesday, Oct 7                                        |
| 7    | Oct 12-16  | maps: stability, periodic orbits, logistic map  
          | No HW due this week                                                        |
          | EXAM1: Friday, Oct 16                                                      |
| 8    | Oct 19-23  | logistic map: bifurcation diagram, periodic window, crisis, renormalization  
          | HW#5 due friday  
          | Project outline due on Wednesday, Oct 21                                    |
| 9    | Oct 26-30  | Fractals and their quantification, dimension algorithms, multi-fractal  
          | HW#6 due friday  
          | Oct 30: Last day to withdraw                                                |
| 10   | Nov 2-6    | Baker's map, Henon map                                                        |
          | HW#7 due friday                                                            |
| 11   | Nov 9-13   | unstable periodic orbit, stable and unstable manifold, bistable system  
          | HW#8 due friday                                                            |
| 12   | Nov 16-20  | composite fractals, embedding theorem, applications to timeseries analysis  
          | HW#9 due friday                                                            |
| 13   | Nov 23-27  | symbolic dynamics and time series analysis  
          | Finally!!!!!!! Thanksgiving break: Nov 26/27                              |
| 14   | Nov 30-Dec 4 | control of chaos, synchronization  
          | No HW due this week!                                                      |
          | Paper due on Monday, Nov 30                                                |
| 15   | Dec 7-11   | shadowing lemma  
          | HW#10 due MONDAY                                                           |
          | Students' project presentations (2 lectures)                               |
| 16   | Dec 14-18  | Last day of instruction (Dec 14); FINAL: Wednesday Dec 16, 1-3pm            |