ORIGINAL COURSE IMPLEMENTATION DATE:	September 1995
REVISED COURSE IMPLEMENTATION DATE:	September 2018
COURSE TO BE REVIEWED: **(six years after UEC approval)**	February 2024

Course outline form version: 09/15/14

OFFICIAL UNDERGRADUATE COURSE OUTLINE FORM

Note: The University reserves the right to amend course outlines as needed without notice.

Course Code and Number: PHYS 484

Number of Credits: 3 Course credit policy (105)

Course Full Title: Nonlinear Physics

Course Short Title (if title exceeds 30 characters):

Faculty: Faculty of Science

Department (or program if no department): PHYSICS

Calendar Description:

Analysis of nonlinear differential equations of physics including exact solutions, phase portrait sketching, approximate solution techniques, forced nonlinear oscillators, the inverse scattering transform, and numerical methods.

Prerequisites (or NONE):	PHYS 221 and PHYS 381.
Corequisites (if applicable, or NONE):	NONE
Pre/corequisites (if applicable, or NONE):	

Equivalent Courses (cannot be taken for additional credit)

Former course code/number:

Cross-listed with:

Equivalent course(s):

Note: Equivalent course(s) should be included in the calendar description by way of a note that students with credit for the equivalent course(s) cannot take this course for further credit.

Transfer Credit

Transfer credit already exists: ☐ Yes ☒ No

Transfer credit requested (OReg to submit to BCCAT):
☐ Yes ☒ No (if yes, fill in transfer credit form)

Resubmit revised outline for articulation: ☐ Yes ☒ No

To find out how this course transfers, see **bctransferguide.ca**.

Total Hours: 75

Typical structure of instructional hours:

Lecture hours	75
Seminars/tutorials/workshops	
Laboratory hours	
Field experience hours	
Experiential (practicum, internship, etc.)	
Online learning activities	
Other contact hours:	
Total	**75**

Special Topics

Will the course be offered with different topics?
☐ Yes ☒ No

If yes, different lettered courses may be taken for credit:
☐ No ☐ Yes, repeat(s) ☐ Yes, no limit

Note: The specific topic will be recorded when offered.

Maximum enrolment (for information only): 24

Expected frequency of course offerings (every semester, annually, etc.): On demand, usually every 3 years

Department / Program Head or Director: Dr. Jeff Chizma	**Date approved:**	May 12, 2017
Faculty Council approval	**Date approved:**	May 26, 2017
Campus-Wide Consultation (CWC)	**Date of posting:**	September 15, 2017
Dean/Associate VP: Dr. Lucy Lee	**Date approved:**	May 26, 2017
Undergraduate Education Committee (UEC) approval	**Date of meeting:**	February 23, 2018

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Identify important examples of nonlinear systems in physics and elsewhere.
- Solve analytically Bernoulli and Riccati differential equations.
- Classify equilibrium points of a dynamical system.
- Sketch qualitative phase portraits of dynamical systems in one and two dimensions.
- Apply the Poincare-Bendixson theorem to search for limit cycles of a dynamical system in two dimensions.
- Generate approximate solutions to nonlinear differential equations using a variety of techniques such as perturbation theory, the Krylov-Bogoliubov method, and the Ritz method.
- Identify key features of nonlinear response curves such as jumps, hysteresis, and subharmonic response.
- Solve the viscous Burgers's equation using the Cole-Hopf transformation.
- Characterize soliton solutions to nonlinear, diffusive wave equations.
- Solve certain nonlinear partial differential equations using the inverse scattering transform.
- Apply techniques such as the Euler method, the Runge-Kutta method, or finite difference methods to calculate numerical solutions to nonlinear differential equations.

Prior Learning Assessment and Recognition (PLAR)

☒ Yes ☐ No, PLAR cannot be awarded for this course because

Typical Instructional Methods (guest lecturers, presentations, online instruction, field trips, etc.; may vary at department's discretion)

Lecture, active learning classroom, project/presentation

Grading system: Letter Grades: ☒ Credit/No Credit: ☐ Labs to be scheduled independent of lecture hours: Yes ☐ No ☒

NOTE: The following sections may vary by instructor. Please see course syllabus available from the instructor.

Typical Text(s) and Resource Materials (if more space is required, download Supplemental Texts and Resource Materials form)

	Author (surname, initials)	Title (article, book, journal, etc.)	Current ed.	Publisher	Year
1.	Enns/McGuire	Nonlinear Physics with Maple for Scientists and Engineers.	☒	Birkhauser	2013
2.	Enns.McGuire	Nonlinear Physics with Mathematica for Scientists and Engineers	☒	Birkhauser	2013
3.			☐		
4.			☐		
5.			☐		

References:

1. Jackson, E. A., Perspectives of Nonlinear Dynamics, Vol. 1 and Vol. 2, Cambridge University Press, 1989, 1991
2. Moon, F. C., Chaotic and Fractal Dynamics, An Introduction for Applied Scientists and Engineers, Wiley, 1992
3. Hilborn, R. C., Chaos and Nonlinear Dynamics, Oxford University Press, 1994

Required Additional Supplies and Materials (software, hardware, tools, specialized clothing, etc.)

Students are strongly encouraged to purchase either a Maple or Mathematica home licence.

Typical Evaluation Methods and Weighting

Final exam: 30%	Assignments: 50%	Midterm exam: 0%	Practicum: %
Quizzes/tests: %	Lab work: %	Field experience: %	Shop work: %
Project: 20%	Other: %	Other: %	Total: 100%

Details (if necessary):

Typical Course Content and Topics

1. Examples of Nonlinear Systems
   a. nonlinear mechanics (simple pendulum, eardrum, nonlinear damping, lattice dynamics)
   b. competition phenomena (Volterra equations, fox rabies in Europe, laser beam competition)
   c. nonlinear electrical phenomena
   d. chemical oscillators
   e. solitons
   f. chaos
2. Methods of Solutions
   a. exactly solvable equations (i.e., Bernoulli, Riccati, elliptical integrals)
   b. variation of parameters
3. Topological Analysis and Graphical Solutions
   a. types of singular points
   b. graphical methods of solution

4. Limit Cycles
    a. oregonator model
    b. first theorem of Bendixon
    c. Poincare-Bendixon Theorem
    d. Prigogine-Lefever Model
5. Analysis Methods
    a. perturbation method (Poisson's & Linstedt's)
    b. Krylov-Bogoliubov Method
    c. Ritz method
    d. Galerkin method
6. Forced Nonlinear Oscillators
    a. iterative solution of Duffing's equation
    b. nonlinear response curve
    c. jump phenomena and hysteresis
    d. subharmonic response
7. Partial Nonlinear Differential Equations
    a. Burger's Equation-Hopf-Cole transformation
    b. elementary soliton calculations
8. Week 11: Inverse Scattering Transformation Method
    a. Lax's formulation
    b. one and two soliton formulas
    c. general input shapes
    d. Zakharov-Shabat/AKNS Approach
9. Numerical Techniques
    a. finite difference approximations
    b. special methods, e.g., Euler, Modified Euler, Runge-Kutta, explicit method of solving PDEs