PHYS385: Methods of Mathematical Physics I

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CATALOGUE DESCRIPTION

Catalogue description: Mathematical techniques used in physics problems. Vector calculus, linear operators, matrices, boundary value problems, and Fourier series.

Prerequisites: MATH 336, and PHYS 300

INSTRUCTOR

Philippe Piot, Prof. of Physics
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(Please use sensible e-mail subject-headings starting with PHYS385)

CLASS MEETINGS & OFFICE HOURS

This class meets on Tuesdays and Thursdays from 2:00pm to 3:15pm in LaTourette Hall, room 227.
I am available to answer your questions or discuss matter related to this course anytime from 8:30am to 1:30pm on Tuesdays and Thursdays. For other times and/or days please send me an e-mail to schedule a meeting.

Notes: Due to travel, four of the classes will be covered by collaborators. The schedules is as follows:

8/25/2015: Introductory lesson (Lesson 1), substitute: Dr. Mihalcea,
8/27/2015: Lesson 2: Introduction + practice with PYTHON: Mr. Halavanau,
9/15/2015: Lesson 7 on complex algebra, substitute: Dr. Mihalcea,
9/17/2015: Lesson 8 on complexe series, substitute: Dr. Mihalcea.

COURSE DESCRIPTION

This course will discuss basics of mathematical methods often employed in physical sciences. It will introduce basic mathematical concepts and apply them, whenever possible, to common problem encountered in electromagnetism, classical or quantum mechanics, and optics. Also the emphasis is on developing mathematical skill the course will also rely on solving problem with numerical methods with main purpose of exploring the limitation of computers and the elegance and prompt capabilities of developing analytic solutions. The class will essentially follow the textbook (see below) starting from chapter 1 "Series" to chapter 7 "Fourier Transform" (included).

TEXTBOOK

The required textbook is *Mathematical Methods in the Physical Sciences* Third Edition, by Mary L. Boas. ISBN-13: 9780471198260 ISBN: 0471198269, published year: 2005 by publisher Wiley.

Mary Layne Boas (1917-2010) was an American mathematician and physics professor. She received a bachelor's degree (1938) and a master's degree (1940) in mathematics at the University of Washington, and a Ph.D. (1948) in physics at the Massachusetts Institute of Technology. She taught physics at DePaul University in Chicago for thirty years, retiring in 1987 to return to Washington. Prior to her time at DePaul University, she served as an instructor in the mathematics department at Duke University. In 2005, at the age of 88, Boas published the third edition of her textbook. She established the Mary L. Boas Endowed Scholarship at the University of Washington in 2008 to recognize outstanding academic achievements by female students in physics.

ASSESSMENT & GRADING

The assessment will consist of biweekly homework, a midterm, four quizzes, and final exam. The grading will be as follows:

Homework	45% of overall grade
Quizzes	15% of overall grade
Midterm	20% of overall grade
Final	20% of overall grade

The Midterm is tentatively scheduled on Tuesday 10/27/2015 and will include series, complex numbers, linear algebra and partial differentiation. The final exam scheduled during the finals week, will have problems on all the course materials. Additionally, the class will incorporate short quizzes (15 mins max) every 3 weeks approximately.

The 15-min quizzes will be small questions and/or very short "drill" problems similar to the examples discussed in the textbook. If you follow the derivations in class and understand the simple examples discussed in the textbook you will have no problem succeeding.

The homework problems will mostly be taken from the textbook and supplemented with some "homemade" problems.

Extra credit will also be offered in someway. Possible extra credit include participation to the class (where many problem will be solved on the backboard), extra homework, etc... These opportunities will be discussed at the class meetings.

The numeric average grade will be computed given the above Table and a letter grade will be assigned following the table below:

Letter grade	Percentage points
A	$\geq 85\%$
A-	$\geq 80\%$
B+	$\geq 75\%$
B	$\geq 70\%$
B-	$\geq 65\%$
C+	$\geq 60\%$
C	$\geq 55\%$
D	$\geq 40\%$
F	$< 40\%$

Further information on NIU grading system can be found at:
http://www.niu.edu/regrec/grading/gradingfaqs.shtml

ACCESSIBILITY

If you need an accommodation for this class, please contact the Disability Resource Center (RDC) as soon as possible. The DRC coordinates accommodations for students with disabilities. It is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or drc@niu.edu. Also, please contact me privately as soon as possible so we can discuss your accommodations. The sooner you let us know your needs, the sooner we can assist you in achieving your learning goals in this course.

SYLLABUS

The lesson plan is as follows (one lesson corresponds approximately to one 1hr15-min class (there are 30 class meetings but one of them will be used for the midterm exam hence 29 lessons are planned).

- Lesson 1: general introduction - introduction to **infinite series** - notion of convergence and divergence
- Lesson 2: computer usage example of PYTHON
- Lesson 3: criteria for series convergence - power series
- Lesson 4: power series - conditional convergence -
- Lesson 5: expansion of function in power series – Taylor and Mc Laurin expansion – examples of use
- Lesson 6: **complex numbers** - complex plane - notation
- Lesson 7: complex algebra

- Lesson 8: complex infinite series and power series
- Lesson 9: elementary functions of complex number - trigonometric and hyperbolic functions
- Lesson 10: **linear algebra** - introduction
- Lesson 11: matrix and determinant
- Lesson 12: vectors & vectorial spaces
- Lesson 13: matrix manipulations and use
- Lesson 14: eigen values and vectors and applications
- Lesson 15: examples of application of linear algebra - vector transformation (translation, scaling, and rotation)
- Lesson 16: **partial differentiation** - introduction - power series of two variables - total differentials
- Lesson 17: approximation - chain rules
- Lesson 18: application of differentiation to extrema search
- Lesson 19: change of variables - differentiation of integrals - other problems
- Lesson 20: **multiple integrals** - introduction
- Lesson 21: change of variable and Jacobian
- Lesson 22: applications
- Lesson 23: **vector analysis** - introduction - vector space (reminders) and vectorial operation (scalar + vectorial products)
- Lesson 24: 3-product - differentiation
- Lesson 25: field, gradient operator ∇ and its applications
- Lesson 26: divergence $\nabla.$, curl $\nabla\times$ and applications
- Lesson 27: **Fourier series** - introduction - periodic functions
- Lesson 28: Fourier series and applications
- Lesson 29: Fourier transforms and applications

SOME GENERIC NOTATIONS

Throughout this course we will use some abbreviated mathematical notation. The table below lists the most commonly used.

symbol	meaning	example
$\mathbb{N}$	set of natural numbers	
$\mathbb{Z}$	set of integer number (pos. or negative)	
$\mathbb{R}$	set of real numbers	
$\mathbb{C}$	set of complex numbers	
$\forall$	for all	$\forall k \in N$
$\in$	in	$m \in \mathbb{Z}$
$\ni$	owns	$\mathbb{Z} \ni q$
$\notin$	not in	$a \in \mathbb{R} \notin \mathbb{Z}$
$\exists$	there is, exists	$\exists n \in \mathbb{N}$ so that...
$\exists!$	there exists one	$\exists! n \in \mathbb{N}$ so that...
$\Leftrightarrow$ iff	is equivalent to, if and only if	$A \Leftrightarrow B$
!	factorial	$n!$
$\lim_{..} \ldots$	limit	$\lim_{x\to\infty} f(x) = 0$

Throughout this class the vectors will be written as bold characters $\boldsymbol{A}$ (e.g. in the textbook, homework and various distributed documents) or with an upper arrow on the blackboard $\vec{A}$.