**Phys 410 – Topics in Mathematical Physics I**

Course Outline: Sept-Dec 2015


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Lectures: 10:30 – 11:30 TWF, ELL 161
Office Hours: TBD, possibly including 9:30-10:30 TWF.
If my door is open, feel free to knock. If I'm busy/hiding, it will be closed.

In this course I will discuss mathematical techniques used to solve physical problems with you. The goal of this course is to help you make connections between some of your preparatory math work and your current and future physics courses.

I assume that you have taken the following math courses:

- MATH 211 – Matrix Algebra (and perhaps MATH 312 Linear Algebra)
- MATH 342 and Math 346 – Differential Equations
- MATH 300 or equivalent – Advanced Calculus
- MATH 301 – Calculus of complex variables

The mathematical techniques covered in this course will be particularly relevant to the following physics courses:

- PHYS 321A, 321B – Classical Mechanics
- PHYS 323, 423 – Quantum Mechanics
- PHYS 326, 422 – Electromagnetism
- PHYS 415 – General Relativity

This course will cover a good deal on the theory and applications of linear algebra – a subject that is a lot broader than you might think. In this course we will discuss groups, normed linear spaces, and linear operators, and then apply this to transformations of coordinate systems. This will lead us to explore tensors and, more generally, representations of groups. Looking at transformations of coordinate systems will lead us to explore curvilinear coordinate systems and then to consider how differential operator transform which will force us to consider how to solve differential equations. A differential equation of extraordinary interest will be the Sturm-Liouville equation, and we will discuss how to solve it and show that a broad, useful class of functions can be seen as a vector. This insight is the basis for orthogonal expansions of functions such as Fourier Analysis. We will develop a number of techniques including variational calculus, as we work towards the 'capstone' piece for this year's PHYS 410: Noether's theorem.
Throughout the course physical examples and problems will be interposed; I will try and draw them broadly, however my interests will skew my choices of examples. I warn you in advance it may end up seeming a little heavy on quantum mechanics.

**References**:

There is no required text for this course. Content will be drawn heavily from
Arfken & Weber, *Mathematical Methods for Physicists* 6th ed. Elsevier.
Lea, *Mathematics for Physicists* Thompson Brooks Cole.
Courant & Hilbert, *Methods of Mathematical Physics*
Other useful references include:
Butkov, *Mathematical Physics* Addison Wesley.
Dennery & Krzwicki, *Mathematics for Physicists* Dover.
Landau & Lifshitz, *The Classical Theory of Fields,* Butterworth Heinemann.
Misner, Thorne & Wheeler, *Gravitation*, Freeman.
Jones, *Groups, Representations and Physics,* Institute of Physics.
Gasiorowicz, *Quantum Physics,* Wiley.
Griffiths, *Introduction to Quantum Mechanics,* Pearson.
Ahlfors, *Complex Analysis,* McGraw-Hill.

**Marking Scheme**:

This class will be taught in a "peer teaching"/"flipped classroom" model, and the marking scheme reflects this. There will be roughly weekly assigned exercises; I will give regular "overview" lectures, typically on Friday, and we will normally spend Tuesday and Wednesday going over the weekly problems. I will ask you, in groups and in rotation, to go over your solution to one of the daily exercises as the leader of our discussion. I will also ask you to submit assignment solutions in groups. My evaluation of you will be based on the assignments and your participation; this is measured by your regular preparation for class, the quality of the presentations you will do, and by the relevance of your in-class comments.

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|---|---|---|
| Assignments: | 40% | Weekly, as described. |
| Participation: | 20% | I want you to come, and to make helpful comments |
| Final Exam: | 40% | Class material and reasonable extensions of it. |

The final exam will be held in the December exam period.

The University of Victoria has a standardized conversion between percentage grades and letter grades. This marking scheme is:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A+ | 90-100 | B+ | 77-79 | C+ | 65-69 | F | 0-49 |
| A | 85-89 | B | 73-76 | C | 60-64 | E | See below |
| A- | 80-84 | B- | 70-62 | D | 50-59 | N | Not Complete |

In all cases, I will use your score (as determined above) to guide the assignment of a percentage grade, and hence a letter grade. I will ensure that assigned grades correspond to the narrative descriptions of the percentage grades as explained in the current Undergraduate Calendar; the descriptions can be found online at:

http://web.uvic.ca/calendar2014-09/FACS/UnIn/UARe/Grad.html.

The grade of E permits the possibility of a supplemental exam; I will only award the grade E to a student who had unsatisfactory performance on the final exam but which was very inconsistent with my evaluation of their in-class mastery of the material. The grade N means you did not complete the course requirements; I will award the grade N to a student who does not write the final exam.

**Final Exam:** I am considering setting an oral final exam during the December exam period.

**Assignments:** This course has an unusual assignment structure. I expect you to be continually working on it at a moderately low level of intensity. The reasons I am structuring the course this way are:

-The courses I learned best in were the ones where I was constantly engaging with the material.

-Trying to explain something to peers makes you understand it more deeply than simply doing calculations.

-I will be able to see what concepts are challenging and what concepts you have mastered; this will let me use lecture time more efficiently.

-Physics is an art – you have to do lots to get an intuition for how to approach calculations in different fields. The goal of this course is to help you synthesize your mathematical knowledge and see how it applies to different areas. Practice is the only way.

**Collaboration:** I encourage you to work together on everything except the final exam. Ask me for help in case of any difficulty. All work submitted must be your own. If you have any doubts about what constitutes appropriate collaboration you should ask me, or refer to the University's *Policy on Academic Integrity*, available in the Calendar on pages 32-33.

**Other issues:** I am willing to arrange reasonable accommodations for illnesses and similar issues. If a problem comes up, please let me know promptly; I'll do what I can to help mitigate it.

**Other Resources:** If you have any problem you are welcome to discuss it with me, however these people may be better equipped to handle non-Physics issues, so please be aware of the following on-campus resources.

Resource Centre for Students with a Disability (472-4946)
Counseling Services (721-8341)

**Tentative Schedule:**

Week 1 – Vector spaces and inner products
Week 2 – Rotations, transformations, and linear operators
Week 3 – Representation and a little on Lie groups
Week 4 – Curvilinear coordinates and parallel transport
Week 5 – Differential operators in curvilinear coordinates
Week 6 – Differential equations and series solutions
Week 7 – The Sturm-Liouville problem
Week 8 – Orthogonal funtions and applications
Week 9 – Green's functions and perturbative methods
Week "the rest" –variational calculus and Noether's theorem.