Physics 231: **Methods of Theoretical Physics**

Instructor:	Flip Tanedo (Phys. 3054)	Meet:	MWF	10:10 – 11am (Chung 139)
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Critical Information

webpage: https://tanedo.github.io/Physics231-2018/
Lecture notes, homework and our course calendar are posted there. Internal material may be posted to `iLearn`.

Please check the course calendar, some days will not be used.

We will use the designated lecture *and* discussion slots as meeting times.

Unofficial Course Description

This is a crash course in (a) mathematical methods for physics and (b) necessary science communication for your Ph.D. The topics are selected to be useful in your graduate coursework and research. This is not a mathematics course, it is *boot camp* for physicists.

Why communication? Two common 'failure modes' of early career scientists are the inability to

- *write* clear papers, fellowship/grant proposals, (non-)academic job applications
- *speak* their research to different audiences.

These skills can make or break an academic career, even though they are never formally taught.

Evaluation

Five homework assignments will be assigned every other Monday.

- **Short homework** [5 pts] due the following Wednesday.
  Quick reminders of key points in lecture, feedback on topics that may not be familiar.
- **Long homework** [20 pts+] due in 2 weeks.
  More detailed calculations, some short writing component. Optional 'extra credit' problems.

Each student will give **one five minute talk** [25 pts] during the course of the quarter. The focus of the talk changes depending on the week. Periodic in-class assessment in the form of **index cards** [1 point] will be used to help me tailor the couse trajectory. No exams. I expect you to *work together* and to abide by the UCR academic integrity policies.

Textbook

The *suggested* textbook is *Mathematics for Physics & Physicists* by Appel (isbn: 9780691131023). You are free to use whatever mathematical physics references you are most comfortable with. Some suggestions are on the course webpage.

Topics

The main theme of the course will be understanding how to solve the partial differential equations that pop up in physics using Green's functions.

1. **Dimensional analysis**. [1 week] How do you tell a physicist from a mathematician?
2. **Differential equations**. [2 weeks] Are differential equations just linear algebra?
3. **Complex Analysis**. [1 week] How do I integrate around poles?
4. **Green's functions**. [4 weeks] How do I solve differential equations?
5. **Special Topics**. [3 weeks] Special topics to be decided. Possibilities include: probability and statistics (how do you know when you've discovered something?), statistical learning (what is machine learning?), differential geometry (what is a magnetic monopole?).

Learning Objectives

By the end of this course, you are expected to attain the following learning outcomes:

1. Use dimensional analysis to determine scaling relations.
2. Understand linear differential operators as infinite dimensional matrices
3. Understand Green's functions as inverse operators
4. Express Green's functions in terms of eigenfunctions of the differential operator
5. Solve for Green's functions using integral transforms
6. Be able to solve simple contour integrals
7. Use contour integrals to solve for Green's functions of common operators
8. Understand the physical consequences of analyticity (e.g. dispersion)
9. Be able to apply Green's function methods to problems in electrodynamics
10. Understand quantum mechanics as an infinite dimensional vector space
11. Understand the basics of frequentist and Bayesian inference
12. Be able to use likelihood to determine the significance of experimental results
13. Understand the statistical foundations of statistical mechanics
14. Understand how to solve differential equations numerically

Additionally, following soft skills will be emphasized:

1. How to write an academic research/personal statement.
2. How to give a brief talk targeted to different types of audiences.
3. How to ask questions in an academic setting.
4. How to answer questions in an academic setting.