Class Meeting: **Tu**, **W** & **F** 10:10-11:30am
Class Location: Heg 106
Office Hours: **TBD**
Email: haggard@bard.edu
Office: Rose 112
Office Phone: (845) 758-7302

Course Description — This course presents mathematical methods that are useful in the physical sciences. While proofs and demonstrations are a core part of the course, we will put the primary emphasis on applications. In an intriguing article the theoretical physicist Eugene Wigner explored what he called the "unreasonable effectiveness of mathematics in the physical sciences". The article concludes

> The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning.

Our aim will be to explore some of the many branches that this miracle has already extended to: how to think of probabilities as a degree of rational belief, the way in which any wave can be broken into constituent and simple harmonic waves, the utility of complex numbers in algebra and in wave physics, the surprising relations that arise between regions and their boundaries, and the remarkable versatility of complex numbers in mapping flows and calculating integrals. In this course we will use differential equations as the mountain pass that we will traverse to get to all of these ideas. Not only are these methods of great utility in applications, but their practice in physics has also often led to new discoveries in mathematics!

Text: *Mathematical Methods in the Physical Sciences*, by M. L. Boas (John Wiley & Sons, 2006)
Recommended text: *Mathematical Methods for Physicists*, by G. Arfken, H. Weber, and F. Harris (Academic Press, 2012)

Grading Structure

Weekly Homework (due on Thursdays?)	35%
Guest lecture	12%
Python project	13%
In-class exam	20%
Take home final	20%

Exams — To practice a time-constrained format we will have one in-class exam. To get a more realistic example of the kind of problems that Math Methods can be applied to we will also have a 4-hour, open-note, self-timed take-home exam. You can study as much as you like using any resource up to opening this exam. However, once you have opened the exam I ask that you only refer to your class notes. I ask that you honor your peers and the effort that we all put into the class by not going over time or referencing any outside materials.

Python project — This should be a stand alone code that you developed yourself to solve a non-trivial Physics problem using mathematical methods. Most successful projects should involve some sort of visualization of your data or results. For example, you might numerically solve a PDE in 2D and plot the solution, illustrate a non-trivial feature of the convergence of Fourier series, or write a code that uses complex analysis to solve a problem in Physics. You should feel free to draw from many example codes, but you should know how everything in your code works and your project should, of course, not be a copy of code that someone else wrote. Your project code is required to: run, be broken into clearly understandable pieces that build up to its main functionality, and be well commented. The scope of these projects is up to you, but please run your ideas by me for approval.

Guest Lectures — The Mathematical Methods sequence is where I usually introduce students to presenting material to their peers. This is one of the most important aspects of the practice of science, and nearly a daily practice. For the guest lectures you will prepare 25mins worth of material to present to your peers. You and I will connect a day or two before your lecture to go through a dry run and correct any small errors. Students tend to enjoy this opportunity!

Course website: `http://faculty.bard.edu/ hhaggard/teaching/phys222Sp21/`

Week	Topics	Chap.
2/1	Probability and finite sample spaces	15
2/8	Combinatorics	15
2/15	Continuous probability distributions and probability densities	15
2/22	Functional Equations and Deriving probability from logic	Class Notes
3/1	Ordinary Differential Equations	15/8
3/8	Separation of variables & PDEs	4/13
3/15	**3/16 & 3/19 Respite Day** Series solution of differential equations	12
3/22	**3/24 Respite Day** Exponential Fourier Series (**In-class exam 3/26**)	7
3/29	Fourier Transforms, Dirac delta function	7
4/5	Sequences & Series	1
4/12	Complex numbers, algebra, functions	2/14
4/19	Complex functions their properties and derivatives Power series.	14
4/22	Complex analysis, Analytic functions, Residues	14
4/26	Contour integration and its applications	14
5/3	**Advising days 5/3-4** Green's functions (**Python project due 5/7**)	7
5/10	Green's functions, Brief look at special functions	7/11
5/17	Python Project Presentations **5/19-25 Completion days**	

Note: I reserve the right to adjust this syllabus during the semester

Calling In & The Honor Principle.

I have read over this syllabus. I agree not to look at solutions manuals or use the internet for anything other than looking up reference information. Finally, I commit to stick to the parameters of all of the exams.

Signed: Date:

Further recommended books: Our class text is all you will need for this course, but if you would like to explore these topics in more depth here are some other books and reference manuals.

A Course in Mathematics for Students of Physics, by P. Bamberg & S. Sternberg
This two volume set takes a very different approach then we will, but covers lots of interesting topics in an insightful way.

Handbook of Mathematical Functions, by M. Abramowitz and I. A. Stegun
While much of this material is somewhere on the web now or can be computed in *Mathematica*, this hefty manual is wonderful to flip through and to gain a bird's eye view of some special functions.

Table of Integrals, Series and Products, by I. S. Gradshteyn and I. M. Ryzhik
A famous handbook. Again it is worth flipping through this some time to get a feel for how people with a lot of familiarity doing these manipulations organize their thinking around it.

An Introduction to Tensors and Group Theory for Physicists, by N. Jeevanjee
An outstanding book, written by a friend, that explains with care the mathematics of tensors and groups. The half of the book on tensors is only about 90 pp and well worth your time. The half on groups is accessible and oriented towards physical applications.

Geometry, Topology and Physics, by M. Nakahara
A common book used in a graduate version of this course that focuses more on geometry and topology.

Mathematics of Classical and Quantum Physics, by W. Byron, R. C. Fuller
An inexpensive Dover book that another physics professor, Paul Cadden-Zimansky, has enjoyed. I am interested to look into it.