Class Meeting: **M**, **W** & **F** 10:10-11:30am
Class Location: Heg 106
Office Hours: **TBD**
Email: haggard@bard.edu
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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 functions as a kind of vector, 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, how to take derivatives and calculate integrals in many dimensions and the surprising relations that arise between regions and their boundaries, and the remarkable versatility of complex numbers in mapping flows and calculating integrals. 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)

Take home — Twice during the semester I will give you take home exams. These will be 4 hour, open note, self-timed exams. You can study as much as you like using any resource up to opening the 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.

Grading Structure	
Weekly Homework (due on Mondays)	30%
Guest lecture	10%
Attendance	5%
In-class exam	15%
Take home exam	20%
Take home final	20%

Homework — There will be homework due every Sunday at 5pm. Complete solutions will be posted. I will grade a portion of the problems on a 0-5 scale. These scores mean roughly the following: 5=clear and complete solution, 4=good solution missing one conceptual point or calculation, 3=clear attempt but with substantive flaw, 2=effort made but incomplete plan, 1=little effort, 0=nothing appearing. I care most about the effort you invest and you can receive credit on this basis. The goal of the homework is for us to engage each other in a discussion of physics regularly, please come and visit as often as you like to discuss. Along these lines, I recommend that you work together; this is invaluable in learning physics. Please write things up yourself to show me and you that you understand it (this helps battle the illusion of explanatory depth, which is worth looking up). Please do not use the internet as a resource for anything but physics books.

Regrades — I will get graded work back to you as quickly as possible. I will post solutions to the homework promptly when the homework is due. This will allow you to correct the problems yourself using the homework corrections guide. Then resubmit your corrected homework by the following Thursday at 5:30pm. I will correct 2 problems from the initial submission and 2 from the resubmitted version. Initially graded problems can also be regraded problems. Because of this regrade policy I cannot accept late work.

Course website: `http://faculty.bard.edu/ hhaggard/teaching/phys222Sp19/`

Week	Topics	Chap.
1/28	Geometry of vector spaces, vector space axioms, vector & wedge products	5
2/4	Vector algebra, Scalar and vector fields and their derivatives	6
2/11	Physical meaning of vector derivatives, Integrals and geometry of Jacobians	5/6
2/18	Coupled oscillators, Wave equations, Fourier Series (**In-class exam 2/22**)	7
2/25	Fourier Analysis, sine/cosine Fourier series, Solving the wave equation	7
3/4	Exponential Fourier Series, Fourier Transforms, Dirac delta function	7/8
3/11	Return to vector derivatives and integrals: gradient and differentials	6
3/18	**Spring Recess**	
3/25	Stokes-type theorems and the curl	6
4/1	Complex numbers, algebra, functions. (**Take-home due 4/8**)	2/14
4/8	Complex functions their properties and derivatives. Power series.	14
4/15	Complex analysis. Analytic functions. Residues.	14
4/22	Contour integration and its applications.	14
4/29	(**Advising days 4/29 & 4/30**) Green's functions	8
5/6	Green's functions. Brief look at special functions	8/11
5/13	Elliptic integrals *Completion days 5/15-5/21*	11

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

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.

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 the take home exams.

Signed: Date: