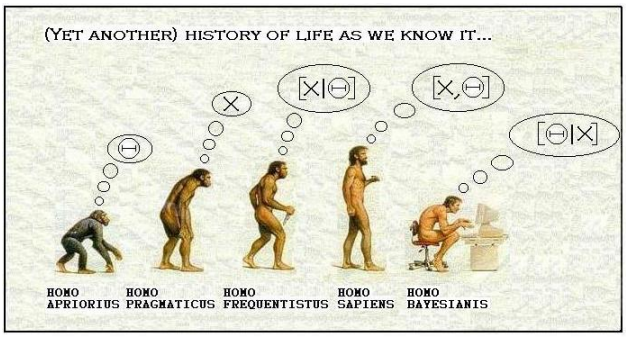
JOHN JAY COLLEGE OF CRIMINAL JUSTICE
The City University of New York
524 West 59th Street, New York, NY, 10019

Syllabus for:MAT/FOS 705, Applied Bayesian Statistics



Professors: Peter Shenkin and **Nicholas Petraco**
Room: 3.19 New Building
Contact hours: Thursdays 6:00pm-8:00pm and Open Door Policy
E-mail address: pshenkin@jjay.cuny.edu
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Course website:
http://jjcweb.jjay.cuny.edu/npetraco/class/fos705/applied_bayes/FOS705.html

Course Description:
Physical evidence comparison has been "put under the microscope" since the 2009 publication of the National Academy of Sciences report "Strengthening Forensic Science in the United Stated: A Path Forward". The implementation of more quantitative and statistically-based standard operating procedures is a foregone conclusion.

The classical "work horse" statistical methods learned in a first year statistics course are known as "frequentist" and "Fisherian" methods. They are extremely useful and have been successfully applied for almost one hundred years. They have well known limits and flaws however. Complementary sets of statistical tools are known as "Bayesian" based methods. Related to Bayes Theorem and relying on a definition of probability as "belief", they offer very intuitive interpretation and a naturally "coherent" methodological framework for inference. Within the last 20 years, as computing power has increased Bayesian methods have become practical for standard scientific applications.

The purpose of this hands-on course is to acquaint forensic science and computing graduate students with Bayesian statistical tools that are applicable to the problems they will encounter in their career. The course will also pay special attention to their relationship with classical methods, as well as issues and pitfalls to be aware of when applying these methods.

Course Learning Goals:

1. Recognize the importance of accuracy and objectivity in collecting/sampling data for applications to the law.

2. Acquire an understanding of the types of data that can be recorded and analyzed for quantitative trace, fire debris, toolmark, and spectrochemical evidence analysis.

3. Acquire an understanding of Bayesian statistical tools that can be used to analyze collected forensic data.

4. Understand the limitations of the Bayesian statistical methods used for data analytics and how not to misrepresent the capabilities of these methods to the courts or clients (ethics).

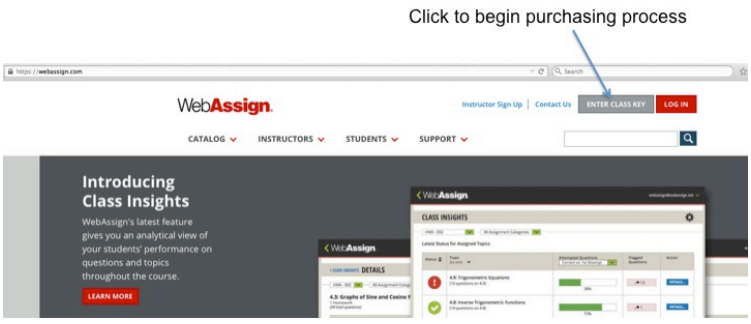
5. Obtain skill with the general computing/statistical software **R** (http://www.r-project.org/) and Bayesian software **Stan** (http://mc-stan.org/), **JAGS** (http://mcmc-jags.sourceforge.net/), **SamIam** (http://reasoning.cs.ucla.edu/samiam/) and **GeNIe** (http://www.bayesfusion.com/).

6. Develop oral and written communication skill as to how to present the results of sophisticated quantitative analysis to officers of the course and lay juries, in terms that are understandable to them.

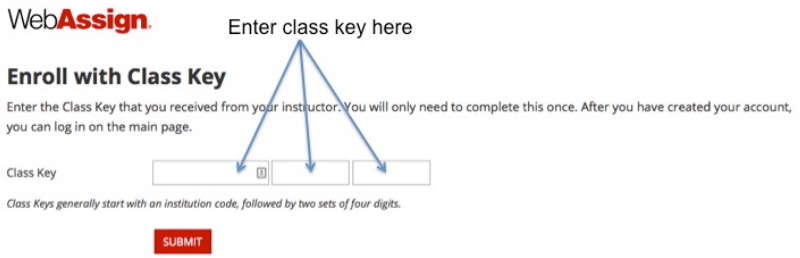
Required textbooks:
R by Example
Jim Albert, Maria Rizzo
ISBN-10: 1461413648

Required Electronic Resources:

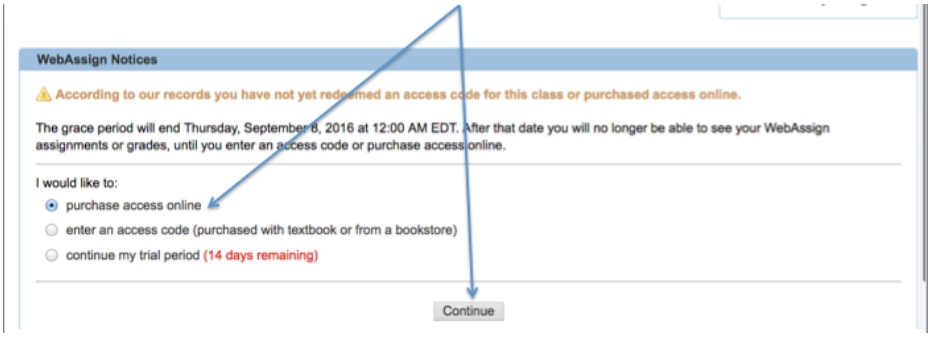
- Webassign: Can be purchased at:
    - **https://webassign.com/**
    - In order to purchase click on "**Enter Class Key**":



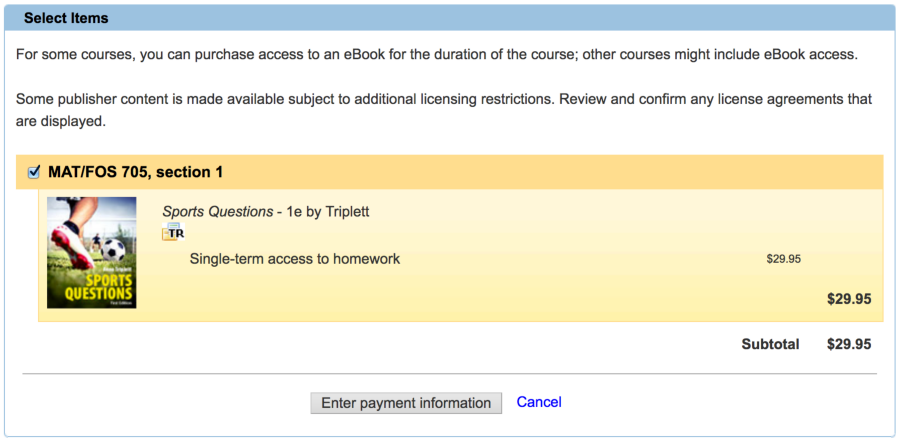
- **<u>You should see a place to enter the class key</u>**:
    - Class Key: **jjay.cuny 6065 3893**



- After logging in/creating-account, select your class and the website will prompt you to purchase the required materials:



- Purchase "MAT/FOS 705 section 1", which should be ~$29.95:



Suggest/Reference textbooks:

The BUGS Book
ISBN-10: 1584888490
(Parametric models. Great all around book for parametric models and applications)

Doing Bayesian Data Analysis
ISBN-10: 0124058884
(Parametric models. Great writing and lots of explanations from many different points of view. Lots of model coding examples.)

Statistical Rethinking
ISBN-10: 1482253445
(Parametric models. Parametric models. Lot's of good tips and alternative presentations.)

Data Analysis Using Regression and Multilevel/Hierarchical Models
ISBN-10: 052168689X
(Parametric models. Great explanations of coding models and interpretation of their output)

Bayesian Computation with R
ISBN-10: 0387922970
(Parametric models. Lots of easy examples to get started with. No special software other than R required.)

Bayesian Data Analysis
ISBN-10: 1439840954
(Parametric models. One of the standards texts for applied parametric models.)

Bayesian Inference in Statistical Analysis
ISBN-10: 0471574287
(Parametric models. A classic and a great read. All conjugate/integrable models.)

Graphical Models with R
ISBN-10: 1461422981
(Graphical discrete models, Bayesian networks. Wonderful resource with lots of examples.)

Bayesian Networks and Decision Graphs
ISBN-10: 0387952594
(Graphical discrete models, Bayesian networks. Applied, but little more technical. One of my favorite books on the subject.)

Risk Assessment and Decision Analysis with Bayesian Networks
ISBN-10: 1439809100
(Graphical discrete models, Bayesian networks. Lots of applications.)

Bayesian Networks for Probabilistic Inference and Decision Analysis in Forensic Science
ISBN-10: 0470979739
(Graphical discrete models, Bayesian networks. Very focused on forensic applications.)

Computer Age Statistical Inference
ISBN-10: 1107149894
(General. A great new book with clear insights into the relationship between classical and parametric Bayesian methods.)

Introduction to Data Analysis with R for Forensic Scientists
ISBN-10: 1420088262
(A great review for classical methods. Very focused on forensic applications. One of the best books around.)

Web resources:
Stan: http://mc-stan.org/documentation/
BUGS: http://www.mrc-bsu.cam.ac.uk/wp-content/uploads/WinBUGS_Vol1.pdf
http://www.mrc-bsu.cam.ac.uk/wp-content/uploads/WinBUGS_Vol2.pdf
http://www.mrc-bsu.cam.ac.uk/wp-content/uploads/WinBUGS_Vol3.pdf
gR: http://people.math.aau.dk/~sorenh/software/gR/
Hugin web: http://www.hugin.com/index.php/resources/
GeNIe web: https://www.bayesfusion.com/resources
https://dslpitt.org/genie/wiki/Main_Page

Grading:

The grades for this course are based on home works (50%), a mid-term and a final (50%).

Topics:

Lecture	Date	Topic
1		Review of visual displays of data
2		Probability, R tutorial/review
3		Conditional Probability, Bayes Theorem and Independence
4		Intro to Bayesian Inference: Conditional Distributions and the concept of data likelihood and priors
5		Working with discrete probability tables
6		Graphical models in brief, Intro to Bayesian Network software
7		Examples of Bayesian Network model building
8		**Mid-Term**
9		Common discrete and continuous distributions
10		Parametric methods: Conjugate and Integrable Models
11		More general models: Intro to Stan/rstan

12		Intro to JAGS/rjags/R2Jags
13		More on choices of prior belief distributions
14		Workhorse Bayesian modeling: Regression
15		Model Checking and comparison
	TBD-May	**Final**

Keeping Up and Studying
This course is packed with information and our schedule will be tight. If you do R practice and a little home work every night you should be fine.

YOU FAIL THIS COURSE IF YOU DO NOT COME TO LECTURE/LAB AND DO NOT DO THE FINAL PROJECT.

Academic Honesty:
Cheating and plagiarism will not be tolerated. If a student is suspected of either of these offenses he or she will be turned into the Provost. I encourage you to collaborate and help each other on projects, however the work you develop and present must be yours. Upon being found guilty a grade of F will be recorded for the course.