

**Your Number One - mathematics of ranking
Pioneer Syllabus**

Term: Summer 2021

Program topic description: What's your favorite? Who's number 1? Who was the greatest ever? Each of these questions involves ranking. Ranking has many applications from determining top colleges to choosing playoff teams. In this program, we will learn several ranking systems including PageRank, the Colley method and the Massey method. PageRank was developed by Google for their search engine results. The Colley and Massey methods are used extensively in sports ranking applications. In this course, we will learn these methods, how to code them, and how to adapt datasets so items can be ranked. Students need to have studied systems of linear equations. We will also need computers to solve the linear systems which can have 30 to 300 unknowns. Coding will be presented in Python. For the final project, students will pick an application to rank, perform the ranking, analyze the results and make conclusions about the strengths and weaknesses of the results.

Professor title and background:

Tim Chartier
Joseph R. Morton Professor of Mathematics and Computer Science, Davidson College
Department of Mathematics and Computer Science
Ph.D. University of Colorado at Boulder

Professor statement:

My research specialty is sports analytics, specializing in ranking methods. I have worked with teams in the NBA, NFL and NASCAR and fielded media questions from ESPN and *The New York Times*. Each year, I work with about 100 students on sports analytics. Sports analytics is an emerging, accessible field that also prepares you for broader mathematical study.

Contact method:

All communication outside of meeting-times will be conducted on the Pioneer LMS (Learning Management System). As per the student agreement, use of email to communicate with the professor mentor during the program is strictly prohibited. If you have problems using the Pioneer LMS, contact your designated Pioneer program manager.

Pioneer LMS link: www.pioneeracademics.schoolology.com

Required program material:

All reading materials will be accessible online and listed in the syllabus.

Software Ect.

- [Anaconda Python](#), Python 3.7, a version of the programming language Python that includes many packages supporting data science and visualization

Learning Goals:

- To apply at least one ranking method (such as the Colley method, Massey method, Elo rating system, or PageRank method) to a real dataset.
- To be able to explain the advantages and disadvantages of an implemented ranking method to a dataset.
- To be able to explain the difference between rating and ranking a dataset.

Grading policy:

- 20%, Preparation and participation in group meetings, including:
 - 10%, Submission of activities for “milestones”
 - 5%, Reading responses submitted online for each reading assignment
 - 5%, Active participation in group meetings
- 80%: Final project, completion of all phases/components:
 - 5%, research proposal and plan
 - 5%, literature review
 - 5%, progress reports
 - 10%, complete draft of final paper
 - 10%, final code and required resource files, including data files
 - 5%, participation in peer review of papers
 - 40%, final paper, which will revise and integrate the previous three papers to form a coherent, through research paper

Assignments and milestones:

Each group session will include some lecture or demo introducing and explaining ideas, plus time for everyone to ask questions and discuss what we’ve gone over. It may include live-demos of student code, and time for students to try out the material we’ve been discussing. Individual sessions will discuss progress on the project/paper and the current phase that is due. Peer review of stages of the project/paper is required.

Session 1: Enter the Matrix with Coding - matrix arithmetic, solving linear systems, and matrix algebra in Python (Group session, 90 minutes)

Assignments due 2 hours before session:

- Activity 0 which includes watching the following videos:
 - Introduction to Matrices (12 minutes) - <https://www.youtube.com/watch?v=bDoqKswdp6c>
 - Matrix arithmetic (4.5 minutes) - <https://www.youtube.com/watch?v=kqWCwwyeE6k>

Session 2: Googling Your Ranking – Google’s PageRank algorithm (Group session, 90 minutes)

Assignments due before session:

- Readings and response completed:
 - Google PageRank, Simplified: A Guide for SEO Beginners:
<https://www.searchenginejournal.com/google-pagerank-explained/350630/#close>
- Activity 1, all milestones

Session 3: Tackling Your Ranking – Colley and Massey ranking systems (Group session, 90 minutes)

Assignments due 2 hours before session:

- Readings and response completed:
 - Bracketology: How can math help?
<http://www.mathaware.org/mam/2010/essays/ChartierBracketology.pdf>
- Activity 2, all milestones

Session 4: Got data? – where to find data and introduction to scraping data (Group session, 90 minutes)

Assignments due 2 hours before session:

- Readings and response completed:
 - The Elo Rating System for Chess and Beyond -
<https://www.youtube.com/watch?v=AsYfbmp0To0>
 - If Your Data Is Bad, Your Machine Learning Tools Are Useless -
<https://hbr.org/2018/04/if-your-data-is-bad-your-machine-learning-tools-are-useless>
- Activity 3, all milestones

Session 5: Exploring beyond the Boundaries: conducting research (Group session, 90 minutes)

Assignments due 2 hours before session:

- Readings and response completed:
 - Why High-School Rankings Are Meaningless – and Harmful -
<https://www.theatlantic.com/national/archive/2013/05/why-high-school-rankings-are-meaningless-and-harmful/276122/>
- Activity 4, all milestones
- Project proposal draft

Session 6: Discuss and refine project proposal/plan, start preliminary list of research articles/resources/data sources. Assign Peer Review partners. (Individual sessions, 60 minutes)

- Within two days after this session, students will exchange research plans and literature review with their Peer Review partner.

Session 7: Update on progress in coding aspects of project, discussion of literature review (Individual sessions, 60 minutes)

Assignments due 2 hours before session:

- Literature review (which includes data source) and bibliography
- Meet with peers for peer review of project proposal prior to session
- Submit your Peer Review Feedback forms

Session 8: Update on progress in coding aspects of project, discussion of literature review (Individual sessions, 60 minutes)

Assignments due 2 hours before session:

- Progress report including outline of the final paper

Session 9: Update on progress, discussion of paper draft and development of plan for revision (Individual sessions, 60 minutes)

Assignments due 2 hours before session:

- Complete draft of final

Session 10: Discussion of project and any last changes to the final paper and code (Individual sessions, 60 minutes)

Assignments due 2 hours before session:

- Submit final paper integrating and revising previous components
- Submit final paper to Pioneer Writing Center at least four days before session

Final deadline: one week after Session 10 (if applicable)

Group sessions and activities: Readings and activities will be assigned between the five group meetings. In addition to doing the reading assignment, students are expected to submit a short reading response (details to be given online). Activities will involve mathematical questions to ensure understanding, downloading data and/or running or writing code; all code must be submitted online before the next group meeting. Students needing extra time to complete an activity should discuss it with Prof. Chartier. All code milestones must be submitted no later than one week after Session 5, or they will earn 0%. Attendance and participation at group meetings is required.

Final project requirements:

The final project will involve reading and summarizing research literature, writing/adapting a program to apply one or more ranking methods to a specific application, and completing a paper that describes the application, ranking method, related work, details of the ranking method's application, and analysis of the results. Work on the project will be completed in a series of phases spread throughout the last five sessions. Each phase will produce a portion of the final paper. Students will get feedback from instructor, peers, and the Pioneer Writing Center throughout the process and are expected to integrate the feedback into revisions of the paper.

Phase 1: Research proposal and plan (5%, part due by Session 5 and Session 6)
Students will propose a topic for their research, including what application they intend to rank and which ranking methods they will use. A draft of the proposal will be shared with peers at the last group session, and it will be completed, including a planned outline of work, for the first individual session. This paper should be 2-3 pages long.

Phase 2: Literature review (5%, due by Session 7)
Research occurs in the context of other work, an ongoing scholarly conversation. Therefore, students will collect relevant research articles (and other resources) and will write a literature review and bibliography (due by Session 7). The review will include a paragraph summarizing each source in the bibliography and describing its relevance to this project. Students should have at least 4 relevant research articles plus book or online resources. This paper should be at least 3 pages (including bibliography). Format bibliography and citations in APA or Harvard style.

Phase 3: Progress report (5%, due by Session 8)
This informal writing assignment will describe what has been accomplished in the programming portion of the project, and will provide a detailed outline of the paper. Included in this will be an outline of the “methods”, the algorithms, the data, and techniques used to analyze the effectiveness of the method, as well as a plan for the final analysis of how well the program works (which may not be completed yet). This paper should be 4-5 pages long.

Phase 4: Complete draft of final paper (10%, due by Session 9)
This should be a complete draft of the final paper, ready for one last round of revisions and improvements. See *Phase 5* for details on expectations for this paper.

Phase 5: Final paper (40%) and final code (10%)
The final paper should integrate the previous three papers into a coherent whole, adding in introduction and conclusion, figures, and including citations and bibliography. Use figures to illustrate the problem and your analysis. Students must address feedback from instructor, peers, and the Pioneer Writing Center by revising and improving every section of the paper. The final paper should be between 15 and 20 pages in length. As before, use APA or Harvard style for citations in the text, and for formatting the bibliography.

Every project will involve applying one or more ranking methods to an application not covered in the course or illustrates how the ranking method can be applied to a larger problem.

Students must submit code that is well-organized and has descriptive comments to make it readable. In addition, any resource and data files required to run the program must also be submitted. Include a text file entitled README.txt that describes the content of all the files submitted, and includes instructions on how to run the program.

Peer review component (5%)

While each research project will be done individually, peers can provide useful feedback on one another's work, and seeing other students' work can bring new ideas about a student's own project. To that end, students will be asked to share their project proposals with their peers and to prepare feedback for peers. Students will be graded on their submission of the peer review form and the quality of the peer review form they prepare for each peer.

1. Students will discuss preliminary research plans during the final group session, Session 5
2. Within two days after Session 6, students will exchange research plans and literature review.
3. Students should complete the Peer Review Feedback Form for their peer. The peer review forms will be submitted as an assignment prior to Session 7 and shared with the student's peer.

Pioneer Writing Center:

All students can use the Pioneer Writing Center to review up to four drafts of their paper. The Pioneer Writing Center guarantees feedback within 48 hours of submission. Students can submit drafts by sending their work to writingcenter@pioneeracademics.com.

Turnitin:

All final papers must be submitted through the "Submit your final paper here" Turnitin assignment in the Course Materials section of the LMS. The Turnitin software will compare the submitted paper against websites, books, journal articles, other student papers etc., and highlight any sections of the paper that are a match for such materials. The Turnitin tool is a part of our dedication to academic integrity. Scholars can check their own papers before submitting the final version for grading, by using the "Check your paper for plagiarism here" assignment, also located in the Course Materials section on the LMS.

Pioneer Research Seminar:

All Pioneer Scholars are required to participate in the Research Seminar, a program that helps students develop the essential research and writing skills they need to successfully complete an excellent independent research project. The Research Seminar offers three live sessions and corresponding asynchronous resources, including a handbook for each unit and additional worksheets. Students are

required to attend all live sessions and read all asynchronous materials. Students will be contacted to register for each live session and have access to the asynchronous materials on the Pioneer LMS. It is your responsibility to carefully study all available resources. Attendance will be reported in the Professor-Student Group on the Pioneer LMS.

The content covered through the Research Seminar is as follows:

- a. Orientation (held before students' first session with their professor)
 - i. How to use Pioneer technology including Zoom, WeChat,
 - ii. How to participate in a college-level academic seminar, including proper interaction during sessions with their professor
 - iii. Program expectations (how to contact their Program Coordinator and Professor, when to expect a response, how to solve common problems)
 - iv. Where to find important materials such as the syllabus
- b. The Research Process (live sessions after the group sessions begin and before individual sessions begin), asynchronous content will be available after the orientation session)
 - i. Brainstorming, evaluating, identifying and revising essential components of the research process, including a research question, research methodology, and research thesis, with specific examples
 - ii. Using the Oberlin library, evaluating sources, and best practices for organizing sources, notes, and information, including specific methods and resources for STEM/Humanities and Social Sciences as well as for individual research disciplines
 - iii. Preparing a research proposal, with STEM/Humanities and Social sciences examples
- c. The Writing Process (live sessions held shortly before or after individual sessions begin, asynchronous content will be available earlier)
 - i. How to work with professors 1:1
 - ii. Large scale planning, outlining, and structuring a research paper, including examples across a variety of research disciplines

- iii. Writing and editing an abstract, including examples across a variety of research disciplines
- iv. Citations and bibliography
- v. How to avoid plagiarism and the importance of academic integrity
- vi. The revision process, including how to use the Pioneer Writing Center, self review, and peer review

Technical support:

For any technical issues relating to program software, the Pioneer LMS or the Oberlin College library system that are not urgent, students should contact their designated program coordinator. For all issues that require immediate attention, message PioneerResearch1 on WeChat. A Pioneer staff member will respond to help resolve any problem quickly.

Rescheduling sessions:

Group sessions cannot be rescheduled once confirmed by the student in writing. If a student misses a group session, Pioneer will endeavor to make a recording of the session available to the student. However, Pioneer cannot guarantee a recording will be available due to occasional technical issues.

During the one-on-one sessions, a student can request up to two sessions be rescheduled if he or she provides a written request to both Pioneer and his or her professor with more than 48 hours notice before the meeting time. Cases of student illness or other emergencies will also be considered with less than 48 hours notice. Once a student has altered two meeting times, he or she may not alter other agreed-upon meeting times in advance of the meetings, regardless of whether he or she continues to provide notice.