MATH 100-01: Symmetry
SPRING 2019

Lecture: MW 3:30–4:50, Jones 306
Instructor: Eric Swartz
E-mail: easwartz@wm.edu
Office hours: MWF 11–12 and by appointment, Jones 133.
Course homepage: We will use **Blackboard** as our course homepage.
Important dates: January 28 (Add/drop deadline), March 15 (Withdraw deadline)

Catalog Description: Symmetry is so fundamental that it is often easily recognized and pleasing to the senses, so vital that it is a guiding principle in seemingly disconnected fields, and so deep that our attempts to understand it have resulted in the development of some of the most important mathematics of the last two-hundred years. In this course, we will ask the big questions: what is symmetry, why is it important, and how has it helped shape different fields? We will explore the mathematics behind symmetry and also examine how symmetry plays an essential role in diverse subjects such as art, biology, and physics. There are no prerequisites for this course.

Textbooks: *Visual Group Theory* by Nathan Carter.
Symmetry: A Journey into the Patterns of Nature by Marcus du Sautoy.
The Symmetries of Things by John H. Conway, Heidi Burgiel, Chaim Goodman-Strauss

Content: The main mathematical content will be *The Symmetries of Things* and *Visual Group Theory*. We will cover as much from *Visual Group Theory* as the natural flow of the class allows. During the first part of the course, we will cover as much of the text *The Symmetries of Things* as we can and discuss tilings of the plane. The text *Symmetry: A Journey into the Patterns of Nature*, which discusses how symmetry relates to different fields, will be required reading throughout the semester.

COLL 100 info: COLL 100 courses are devoted to "big ideas:" significant questions and concepts, beliefs and creative visions, theories and discoveries that have shaped our understanding of the world. COLL 100 courses challenge students to think rigorously and to develop and practice communication skills beyond the written word. COLL 100 courses introduce students to the College's library and other academic resources and to the ways in which information is accessed, evaluated, and communicated. All COLL 100s carry 4 credits.

Course Objectives:

- Explore the mathematics behind symmetry.
- Get an overview of how symmetry has shaped different fields by exploring the overarching concept in the areas of art/architecture, music, biology, chemistry, games, physics,

and mathematics.

- Learn how to read scientific/mathematics articles and texts critically.
- Learn how to reason mathematically and what it means for a statement to have a mathematical proof.
- Learn how to organize and give effective multimedia presentations.
- Learn how to utilize the resources available at the library and how to conduct a search within the scientific literature.

Grading:

Attendance/Participation:	20%
Quizzes:	10%
Critiques of Presentations:	5%
Mathematical Argument/Group Presentation:	25%
Individual Project/Presentation:	40%

Final letter grades are assigned using the scale: A 93–100, A- 90–92, B+ 87–89, B 83–86, B- 80–82, C+ 77–79, C 73–76, C- 70–72, D+ 67–69, D 63–66, D- 60–62, F <60

Attendance/Participation: Participation is vital to this class! Students will be expected to attend class regularly and should be prepared to participate in class discussions and group activities. I do not expect you to understand all of the material we cover just through reading. It can be difficult! I do expect you to engage with the material as best as you can. Add to discussions when you can, and ask questions!

Quizzes: Most Mondays there will be a short quiz. I will not expect you to solve difficult mathematical problems on the quizzes. The quizzes will largely be to check how well you have followed along with concepts that we have covered recently in class and that you have been keeping up with the readings.

Critiques of Presentations: Students will be expected to attend three university talks outside of class throughout the semester. One talk should be a mathematics colloquium (if possible) or in another closely related field (as approved by the instructor). Another talk should be in an area that interests the student. The final talk should be in an area the student knows little-to-nothing about but is curious to learn more. Students will evaluate the presentations they attend based on a rubric that will be provided to the students.

Mathematical Argument and Group Presentation: This project will be divided into three stages: a written mathematical argument (worth 10% of final grade), a (practice) presentation of the argument to the instructor (5% of final grade), and a presentation to the class (10% of final grade).

Students will be divided into groups by the instructor, and each group will be assigned a mathematical problem to which they must provide a complete mathematical proof. Once assigned, students will have two weeks during which they can turn the argument in as many times as they like to the instructor to receive feedback. They will only be graded on the final version, which is due at the end of the two week period. The written argument will be graded both for correctness and for clarity of exposition.

After the final version of written arguments are returned to students with feedback, they will have to present a solution in a (practice) presentation to the instructor. Presentations will be graded based on content, structure, and the speaker(s). (A detailed rubric on how presentations will be graded will be provided with the assignment.)

Finally, students will present the argument to the class, explaining the argument with a Powerpoint (or Beamer) style presentation. Presentations will be graded based on content, structure, technical presentation, and the speaker(s). (A detailed rubric on how presentations will be graded will be provided with the assignment.)

Project: Each student will conduct a research project over the course of the semester. The project will be on a topic of the student's choosing related to symmetry, applying ideas learned throughout the semester. (An example of such a project would be an analysis of the symmetry of the work of a particular artist.) The project will be divided into stages: initial proposal (5% of final grade); first draft of paper on subject (5% of final grade); critique of peer's paper (5% of final grade); practice presentation to instructor (5% of final grade); presentation to class (10% of final grade); final version of paper (10%).

The project paper must include a written analysis of the subject (ten to twenty pages in length, 12 point font, double spaced), but the project must also go beyond the written word and include some other form of visual/aural communication. Projects will be graded based on scope, content, correctness, and presentation of ideas. Ambitious projects are encouraged and degree of difficulty will be taken into account!

Project Presentations, which will be summaries of the research projects the students have conducted over the course of the semester, will be ten to fifteen minutes long and take place during the last two weeks of class. (A detailed rubric on how presentations will be graded will be provided with the assignment.)

Honor code: Students are expected to uphold the honor code in this class. Any suspected infraction will be reported.

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SCHEDULE
(Subject to change!)

January 16: Discussion of class structure, Introduction

January 23: *The Symmetries of Things* discussion

January 28: *Visual Group Theory* discussion, **Quiz 1**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapter 1
January 30: *The Symmetries of Things* discussion.

February 4: *Visual Group Theory* discussion, **Quiz 2**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapter 2
February 6: *The Symmetries of Things* discussion

February 11: *Visual Group Theory* discussion, **Quiz 3**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapter 3
February 13: *The Symmetries of Things* discussion

February 18: *Visual Group Theory* discussion, **Quiz 4**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapters 4–5
February 20: *The Symmetries of Things* discussion

February 25: *Visual Group Theory* discussion, **Quiz 5**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapters 6–8
February 27: *The Symmetries of Things* discussion, Symmetry in the Art of M.C. Escher. **Written mathematical arguments assigned.**

March 4–6: Spring Break

March 11: *Visual Group Theory* discussion.
March 13: Library visit (tentative)

March 18: Symmetry in Music, Discussion, **Quiz 6**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapter 9. **Initial project proposals due.**
March 20: *Visual Group Theory* discussion. **Written mathematical arguments due.**

Group presentations to instructor will take place this week.
March 25: Symmetry of Molecules, **Quiz 7**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapter 10
March 27: *Visual Group Theory* discussion. **Resubmit project proposals.**

April 1: *Visual Group Theory* discussion, **Quiz 8**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapter 11
April 3: Group Presentations

April 8: *Visual Group Theory* discussion, **Quiz 9**. Readings: *Symmetry: A Journey into the Patterns of Nature* Chapter 12
April 10: Solving a Rubik's Cube. **First draft of project analysis due.**

April 15: *Visual Group Theory* discussion, **Quiz 10**.
April 17: *Visual Group Theory* discussion. **Critique of peer's project due.**
Presentations of projects to instructor will take place on Thursday and Friday.

April 22–24: Individual Presentations

May 3: Individual Presentations. **Final draft of project analysis due.**

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PROJECT

Each student will conduct a research project over the course of the semester. The project will be on a topic of the student's choosing related to symmetry, applying ideas learned throughout the semester.

EXAMPLES OF PROJECTS: Symmetry in the work of [insert painter's name]; An in-depth look at the symmetry of [chemical compound(s)]; Why does the general fifth degree equation have no formula for a solution like a quadratic equation does? (ambitious)

ASSIGNMENT #1: Submit an initial project proposal by Monday, March 18. Your proposal should include a title, an outline of what you will address/questions you will answer in your project, and a list of possible references, and it should be about one page in length. Pick something that you are curious to examine more deeply. A good exercise might be to start with a specific field you are interested in, such as architecture or biology, and start narrowing from there. Ambitious projects are encouraged, and I will gladly assist if the mathematics you need to use goes beyond the scope of this course! You will receive feedback later that week, and you will resubmit a project proposal on Wednesday, March 27, taking this feedback into account.

ASSIGNMENT #2: Submit two copies of a draft analysis of your subject (between ten and twenty pages in length, 12 point font, double spaced) by Wednesday, April 10. In conjunction with your written analysis, your project must go beyond the written word and include some other form of visual/aural communication. Projects will be graded based on scope, content, correctness, and presentation of ideas. It is permissible to submit the first draft of the assignment later that week, but you will automatically lose 1 point (out of five) for each day that it is late.

ASSIGNMENT #3: You will be given a draft of another student's research project to critique on Wednesday, April 10. You will use the same rubric as I use (and which will be distributed to you) to evaluate the project. Turn in a copy of your evaluation to me and to the project's author on Wednesday, April 17.

ASSIGNMENT #4: Prepare a project presentation, which will be a summary of your project for the class. Each presentation should be ten to twenty minutes long. Practice presentations to the instructor will take place on Thursday, April 18, and Friday, April 19, and presentations to the class will take place during the last week of class (April 22–24) and during the scheduled Final Exam block (9 AM – 12 PM on Friday, May 3).

ASSIGNMENT #5: Students will receive feedback both from me and from another student on April 17. Incorporating this feedback, you will turn in a final version of your project by Friday, May 3.