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# SYLLABUS

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## SYLLABUS

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## COURSE OVERVIEW

**Note: For Spring 2021, students can choose between taking this course fully online or in person.**

In this first year seminar, students will explore ideas from topology and geometry and their application to symmetry patterns. We will start by building intuition for properties of surfaces with games and visualization exercises. We will develop tools to distinguish surfaces and prove impossibility theorems. Next, we will study the curvature of surfaces and discover connections with our previous work in topology.

The focus of the course will then shift to symmetry and the identification of repeating patterns in the world around us, from snowflakes, to frieze patterns on campus buildings, to designs on tapestries and wallpaper, to paintings like those of M.C. Escher. We will relate symmetry patterns to their folded-up counterparts, called orbifolds, and use tools from geometry and topology to determine which patterns are possible and which can never be achieved. We will extend our analysis to spherical and hyperbolic

patterns, uncovering some of the shocking differences between Euclidean and non-Euclidean geometry.

Course assignments will include readings, mathematical investigations, design projects such as virtual and physical kaleidoscopes, quizzes, and a final project. The final project will allow students to pursue a theoretical topic (e.g. hyperbolic tilings or map projections), an application (e.g. quasicrystals or patterns on neckties), or a maker project (e.g. 3-dimensional pattern kaleidoscopes or hyperbolic quilts). No prerequisite knowledge is needed.

## COURSE GOALS

### Content specific

By the end of this course, you will be able to

- *Analyze topological surfaces, using properties and invariants to distinguish and classify them*
- *Define and calculate curvature of surfaces*
- *Describe connections between topology and geometry*
- *Analyze isometries of the plane, their orders, inverses, and compositions*
- *Classify all types of rosettes, frieze patterns, and wallpaper patterns*
- *Use ideas from topology and geometry, including curvature, Euler number, and orbifolds, to explain why certain symmetry patterns are impossible*
- *Create symmetry patterns with repeating motifs, using software and pen and paper*

### Methodological

Throughout the course, you will

- *Encode visual information using models, diagrams, numbers, and equations*
- *Generate conjectures about patterns and shapes based on examples and experimentation*
- *Construct logical arguments and proofs involving cases, invariants, and proof by contradiction*
- *Express mathematical ideas orally and in writing*
- *Describe symmetry patterns in art, architecture, and nature*

### General Education Quantitative Reasoning Learning Outcomes

As part of the General Education curriculum Quantitative Reasoning focus capacity, this course will enable students to

1. *Connect with a faculty member early in the educational process.*
2. *Learn intensively among a small cohort of students.*
3. *Analyze and communicate issues associated with a specific advanced topic*

3. *Analyze and communicate issues associated with a specific, advanced topic, covering a wide range of knowledge.*

4. *Produce knowledge through self-directed inquiry and active learning.*

Students will generalize from examples to create conjectures about surfaces and symmetry patterns, and then use logical arguments and counterexamples to prove and disprove these conjectures.

## Recurring Capacities

Math 70 will sustain the recurring capacities of inquiry that guide the general education mission as follows:

1. *Pose problems and questions that require systematic thinking about evidence, argument and uncertainty*
  - Students will form conjectures and use proof and counterexamples to support or discredit these conjectures.
  
2. *Consider its content in the context of human difference between and within societies; the full range of legitimate debate in its field; and/or change over time*
  - Students will study the common mathematical structures underlying the symmetry patterns used by different human cultures as well as the variety of implementations and styles of symmetry patterns across cultures.
  
3. *Require*
  - a. *Writing totaling at least 10 pages in length, or the intellectual equivalent.*
    - Students will complete weekly written homework assignments that frequently require persuasive arguments. Students will complete a written report of 5 – 10 pages on their final project.
  
  - b. *Presenting material to the class, small groups, or the public through oral presentations, webpages, or other means that enable corroboration of fact and argument.*
    - Students will present arguments in class, add captioned photos to the class's Instagram account, and present their final projects to the class.
  
  - c. *Collaborating in pairs or groups to learn, design, solve, create, build, research or similar.*
    - Students will analyze data, construct counterexamples, and construct proofs in groups during class. Students will work on final projects in groups.

## COURSE TOPICS

1. Topology of Surfaces
  - a. Gluing diagrams
  - b. Properties of surfaces (orientability, boundary)
  - c. Connected sums and punctures
  - d. Classifying surfaces
  - e. Euler number
2. Geometry of surfaces
  - a. Curvature
  - b. The Gauss-Bonnet Theorem
3. Isometries of the plane
  - a. Rigid motions / isometries
  - b. Combining isometries
  - c. Kaleidoscopes
4. Rosettes and Frieze Patterns
  - a. Identifying and classifying rosette patterns
  - b. Identifying and classifying of frieze patterns
  - c. Paper cutting
5. Wallpaper patterns
  - a. Identifying features of wallpaper patterns
  - b. Orbifolds
  - c. Classifying wallpaper patterns
  - d. Spherical and hyperbolic patterns

## COURSE STRUCTURE

Class meets three hours per week MWF 10:10 - 11:00. Students can choose to attend in person in Global Center 1005 or remotely on Zoom. Class activities will include interactive lecture, problem solving in small groups, and hands-on explorations.

## PREREQUISITES AND TARGET AUDIENCE

Math 70 is a First Year Seminar, intended for first year students who would like to explore ideas about shape and symmetry. There are no prerequisites for this class.

## INSTRUCTOR

Linda Green, [greenl@email.unc.edu](mailto:greenl@email.unc.edu)





## REQUIRED MATERIALS

### TEXTBOOKS

You will need:

1. [\*The Shape of Space\*](#) (3<sup>rd</sup> edition) by Jeffrey Weeks, ISBN: 978-1138061217 (required)
2. [\*The Symmetries of Things\*](#) by John Conway, Heidi Burgiel, and Chaim Goodman-Strauss, ISBN: 978-1568812205 (strongly recommended)

### PIAZZA

Instead of emailing the instructor or TAs with questions about homework problems or logistics, please post your questions on Piazza. Other students, instructors, and TAs can answer them there for the benefit of all students. If you were not automatically added to Piazza, you can register yourself here: [piazza.com/unc/spring2021/math70](https://piazza.com/unc/spring2021/math70). There is no charge for using Piazza.

### GRADESCOPE

Quizzes, recitation problems, and projects will be graded via Gradescope. If you were not automatically added, you can enroll yourself at [gradescope.com](https://gradescope.com) using the entry code JB3476. Please use your UNC email. There is no charge for using Gradescope.

### ZOOM

The following Zoom URLs will be used for this course:

- Lecture TuTh 10:10 - 11:00 am: <https://zoom.us/j/95425575949>
- Linda Green's office hours: <https://zoom.us/j/597182151>

### APPS

1. Geogebra: We will use the geometry calculator at <https://www.geogebra.org/geometry> and other tools. Please make a free account.
2. Padlet: We will use [padlet.com](https://padlet.com) to organize and analyze symmetry patterns.
3. Instagram: Students can earn participation points by posting symmetry patterns to the instagram account:
  - Username: Math70UNC
  - Password: symmetry
  - Email: [greenl@email.unc.edu](mailto:greenl@email.unc.edu)

## ASSIGNMENTS AND EXAMS

The following components of this course will contribute to your grade.

### HOMework

Homework will be posted on Sakai after every class. Students are encouraged to work together on homework, but each student must hand in a separate assignment, written up in their own words, crediting help from other students as applicable.

Homework will be collected once a week, with due dates posted on Sakai and announced in class. Homework will be graded based on the following criteria:

- **Completeness:** All assigned work should be included. Please consult Sakai for a current list of assigned work and point values. Entries should address topics at a depth commensurate with your mathematical background and prior knowledge of the topic.
- **Exposition:** If you are presenting the answer to a question, state or paraphrase the question. If you are giving an argument, explain what the point is before you launch into it. If you are giving instructions, have a friend test them for you. Explain things clearly, at a level that a peer in the class could understand.
- **Accuracy:** Some homework questions will have correct answers. Stated facts should be correct, and conjectures should be labeled accordingly.

Your lowest homework score will be dropped if at least 80% of students complete the end of semester course evaluation.

### QUIZZES

There will be quizzes given in class approximately once every two weeks. Quiz dates and topics will be posted on Sakai and announced in class. Some quizzes will be two stage quizzes, in which you complete the quiz first individually, and then again in groups of ~3. Your lowest quiz grade will be dropped.

### PARTICIPATION

Participation is a major component of a first year seminar. Students are expected to come to class prepared, to participate wholeheartedly in group work and class discussions, and to contribute information to the Sakai wiki as assigned. Students are also expected to observe and record symmetry patterns that they find around them while outside of class and post on Instagram. Participation will be graded based on attendance, engagement in class, and Instagram posts, and each student's participation grade will be computed by dividing the their total number of points by 100.



Students can earn up to 2 points for each class period: 2 = present and engaged, 1 = present but not fully engaged, or only present part of the class period

Students can earn up to 2 points for each Instagram post: 2 = relevant post with all required information in comments, 1 = relevant post missing some of the required information

Use this Instagram account to post photos of symmetry, tilings, and other topics relevant to the class:

- Username: math70UNC
- Password: symmetry
- Email: [greenl@email.unc.edu](mailto:greenl@email.unc.edu)

For each post, please include in the comments:

- your name
- the location (where you took the photo)
- some mathematics related to the photo, such as its symmetry type (e.g. this is 4\* symmetry)

## FINAL PROJECT

The final project will allow students to delve more deeply into a theoretical topic or an application of their choice. Students can work individually or in groups of 2, 3, or 4. Possible topics will be listed on Sakai, but you do not need to limit yourself to topics on the list. The final project should include a 5 - 10 minute presentation to the class and a 1000 - 2500 word written report (about 4 - 10 pages double spaced). Some projects will also include a physical component, such as a mathematical work of art. For projects that include a physical component, the written component can be briefer and may take the form of a description of how you made the project or a guide to using it.

## GRADING

Assignment	Percentage of Final Grade
Homework	35%
Participation	10%
Quizzes	30%
Assignment	Percentage of Final Grade

Final Project	25%
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## GRADING SCALE

Percentages will be converted to letter grades according to the following scale.

Letter Grade	Percentage
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	60–66%
F	0–59%

## COURSE POLICIES

### COMMUNICATION

Please post questions about homework and class logistics on Piazza.

If you have a private question, specific to your individual circumstances, you can post privately on Piazza or send the instructor an email. If the instructor does not respond to an email or private message within 48 hours, please send a second message.

If you need to have a private conversation, not appropriate for a public office hours setting, please book an appointment via [lindagreenunc.youcanbook.me](https://lindagreenunc.youcanbook.me).



## ILLNESS

Please do not attend class or recitation in person if you are sick, think you might be sick, or have been in contact with someone who is sick. Please attend online instead. If you are too sick to attend, you can watch a recording of the class posted on Zoom instead.

## LATE WORK

Homework will be accepted late for a 10% per day penalty.

## MAKE-UP TESTS AND QUIZZES

No make-up quizzes will be given. Quizzes can be given early if the student will be absent for university athletics, an academic field trip, or a religious holiday and makes prior arrangements with written documentation at least a week in advance. Exceptions may be made in extreme circumstances with intervention from the Dean of Students. The lowest quiz score will be dropped, so one missed quiz will not affect your grade.

## HONOR CODE

It is expected that each student in this class will conduct themselves within the guidelines of the UNC Honor System, described at <http://studentconduct.unc.edu/students>.

On homework, students are encouraged to work together in pairs or small groups, provided that all participants are contributing and the collaboration benefits the learning of all involved. Simply copying or trading answers is an instance of cheating. Homework are open book and open notes, and calculators and computer apps are permitted.

Quizzes are closed book and closed notes unless otherwise specified. Calculators are permitted unless otherwise specified. Individual quizzes must be completed individually, group quizzes must be completed in assigned groups. It is an instance of cheating to give or receive help on a quiz, except from the instructor or from members of an assigned group for group quizzes. In particular, it is a violation of the honor code to post quiz or test questions on the internet or access questions that others have posted, or to get help from online problem solving services, whether computerized (e.g. Wolfram Alpha) or staffed by live humans (e.g. Chegg).

If you are not sure what is permitted on any assignment, please ask!

In addition to avoiding actual academic dishonesty, please avoid appearances of academic dishonesty. In particular, please silence and put away cell phones before any quizzes are handed out, please avoid the appearance of looking at other students' papers, please avoid accessing any internet sites that are not specifically permitted during online assessments. In order to maintain a proper testing atmosphere, the

instructor may ask students to switch seats before or during an in-person exam and the instructor will proctor students taking online assessments via Zoom or using other online proctoring tools.

Students who take assessments online are responsible for establishing a proper testing environment in their location. This includes silencing and putting away all cell phones and other devices not permitted for the assessment, closing all laptop apps and browser windows that are not required for the assessment, putting away all books and notes, and securing a quiet space free from interruptions.

Students who observe a violation of the honor code should report it to the instructor. The instructor will report any suspected honor code violations to the Honor Court.

## HELP

There are several ways to get help for this class.

## OFFICE HOURS

- Linda Green's office hours: Tu 4:00 – 5:00, Th 3:00 – 4:00 (check Piazza for updates)
- Office hours zoom meeting number: 597182151

## TUTORING

- The math department offers free online tutoring at the Math Help Center, M - F and possibly weekends.
- The Learning Center sponsors free drop-in Peer Tutoring on Tuesday and Wednesday evenings from 6 - 8 pm. Additional information is here: <https://learningcenter.unc.edu/drop-in-peer-tutoring/> between 6:00 and 8:00 pm on Tuesday and following the directions there.
- The Learning Center also has tutoring by appointment, Sunday through Friday. Students can make peer tutoring appointments by going to <https://success.oasis.unc.edu>.
- The math department maintains a tutor list of math grad students offering paid private tutoring.

## ACADEMIC COACHES

- The Learning Center has two math coaches, Gonzalo and Jackie, who can give you tips on how to study for and succeed in a math class. Students can make academic coaching appointments by going to <https://success.oasis.unc.edu>

## ACCESSIBILITY RESOURCES

UNC-Chapel Hill facilitates the implementation of reasonable accommodations for

students with learning disabilities, physical disabilities, mental health struggles, chronic medical conditions, temporary disability, or pregnancy complications, all of which can impair student success. See the ARS website for contact and registration information: <https://ars.unc.edu/about-ars/contact-us>

## COUNSELING AND PSYCHOLOGICAL SERVICES

CAPS is strongly committed to addressing the mental health needs of a diverse student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. Go to their website:

<https://caps.unc.edu/> or visit their facilities on the third floor of the Campus Health Services building for a walk-in evaluation to learn more.

## QUESTIONS ABOUT THE COURSE?

Post on [Piazza!](#) Please make it public so that other students can benefit. Anonymous posts are fine.

If you have a private concern, please make a private post on Piazza to the instructor only, or email the instructor directly: [greenl@email.unc.edu](mailto:greenl@email.unc.edu).

## QUESTIONS ABOUT TECHNOLOGY?

Contact the ITS Service Desk:

- Phone (919) 962-HELP (4357)
- Chat: <https://help.unc.edu/>
- [Online Help Request](#)
- Twitter: @uncservicedesk
- Facebook: uncservicedesk
- YouTube: unchelpdesk
- Instagram: uncservicedesk

