

**University of Indianapolis**  
**Department of Mathematical Sciences**  
**MATH-540 MODERN GEOMETRIES (4 cr. hrs.)**  
**Full Winter/Spring, 1/16/24 - 5/4/24**  
**Online Asynchronous**

**Instructor:** Jeff Oaks  
**Office:** Martin Hall 357  
**Telephone:** 317-618-1956  
**E-mail:** [oaks@uindy.edu](mailto:oaks@uindy.edu)

**Virtual Office Hours:** TBA

**Description:**

A review of the basic techniques of straight edge and compass construction, including constructions requiring propositions from Book III of Euclid's *Elements* (ca. 300 BC), gives students an intuitive foundation necessary for the approaches that follow. First is an overview of the nature of postulates and propositions in Euclid, which are radically different from their modern counterparts. From there, the bulk of the course is devoted to geometry based in Hilbert's axioms (1899), where the theory of plane geometry is built with an eye toward understanding the dilemma of Euclid's parallel postulate. The historical development leading from Euclid to hyperbolic and elliptic geometry is then situated in this mathematical context.

**Prerequisites:**

Calculus I, II, and linear algebra, and an introductory course on mathematical proofs.

**Texts:**

Euclid's *Elements*, translated by Richard Fitzpatrick. Available online for free:

<https://farside.ph.utexas.edu/books/Euclid/Elements.pdf>

Robin Hartshorn, *Geometry: Euclid and Beyond*. New York: Springer 2000. (hardcover \$45.79)

B. A. Rosenfeld, *A History of Non-Euclidean Geometry*. New York: Springer, 1988. (online version is \$129.00)

(This book is too expensive. I will try to find an alternative before students begin buying it.)

**Course Outline:**

Ruler-and-compass constructions, to be conducted in the context of Books I-III of  
Euclid's *Elements*

Euclid's five postulates and the commentary of Proclus (412-485 CE)

Structure of Euclid's propositions and non-arithmetized geometry

David Hilbert's axioms (1899):

Incidence axioms

Betweenness axioms

Congruence axioms

Explore different models and prove theorems in these axioms

Neutral, Euclidean, and hyperbolic geometry

Exterior Angle Theorem

Saccheri and Lambert quadrilaterals  
 Playfair's and other axioms equivalent to Euclid's fifth postulate  
 History of the parallel postulate:  
   Greeks: Euclid, Ptolemy, Proclus, Aghanis, Simplicius  
   Arabic authors: Al-Jawhārī, Thābit ibn Qurra, Ibn al-Haytham, al-Khayyām, Nasīr al-Dīn al-Ṭūsī  
   Europeans: Cataldi, Clavius, Clairaut, Lambert, Legendre  
 Discovery of non-Euclidean geometry: Saccheri, Bolyai, Lobachevsky, Gauss  
 Exploring hyperbolic geometry: Poincaré's model, limiting rays, and related theorems

**Course Requirements:** Grades are based on homework and exams.

Homework: 30%

Homework will be assigned regularly and answers will be posted in Brightspace after they are due.

Exams: 70%

There will be three one-hour exams and a two-hour final exam. The one-hour exams count for 15% of your grade, and the final counts for 25% of your grade.

Homework: assignments will be listed and due on BrightSpace (unless otherwise announced).

Exams: The exam dates and times will be listed on Brightspace. If you cannot take the exam with the rest of the class, you must contact the instructor beforehand.

**Assignment Schedule:** TBA

**Test Schedule:** TBA

**Grading Method:**

Letter Grade	Average	Letter Grade	Average
A	92 - 100	C	72 - 77.9...
A-	90 - 91.9...	C-	70 - 71.9...
B+	88 - 89.9...	D+	68 - 69.9...
B	82 - 87.9...	D	62 - 67.9...
B-	80 - 81.9...	D-	60 - 61.9...
C+	78 - 79.9...	F	below 60

The instructor reserves the right to make positive changes to the grading scale however percentages are **not** rounded up to give students higher grades.

**Course Format:** The course is a synchronous and online, and lectures will be recorded. The recording allows for accessibility to instruction for those not able to attend the online lecture live. The instructor will post links to online resources, homework assignments, and timed online tests in Brightspace. The instructor will respond to emailed questions and is available for zoom appointments to answer questions and other consultation.

**Tips on taking online course:** <https://www.math.tamu.edu/graduate/distance/tips.html>

**Academic Integrity** The students, faculty, and administrators of the University of Indianapolis commit themselves to the highest level of ethical conduct in academic affairs. The University of Indianapolis, therefore, adopts regulations concerning Academic Misconduct to safeguard the academic integrity of the institution. Academic Misconduct includes, but is not limited to, the following circumstances: (A) Cheating, (B) Fabrication, (C) Plagiarism, (D) Interference, (E) Violation of Course Rules, (F) Facilitating Academic Dishonesty, and (G) Abuse of Confidentiality. For a full statement of the policy refer to the University of Indianapolis Student Handbook, Section I, Academic Information