Homological Algebra (Math 607)
Fall 2021

Meeting times:	Tue. and Thurs. 12:00–1:20pm in 210 University Hall
Instructor:	Ben Elias
Office:	Fenton 210, x6-5629
Office hours:	TBD.
E-mail:	belias@uoregon.edu
Course website:	http://pages.uoregon.edu/∼belias/Classes/607-fall-2021/
Midterm:	None.
Final:	None.

Textbook: Weibel's Homological Algebra, and other online resources.

Homeworks and Grading: While coded as a 607 course, this is not really a topics course, but more a standard course on a fundamental topic in algebra. These are widely used tools which most students are likely to use at some point in their career at UO. I believe exercises are a crucial way to acquire tools, and that students who do not do exercises tend to fall behind and not get as much out of the course.

My intent is to assign approximately 1.5 hours of homework per week. It will come in the form of two assignments, one for each lecture, not necessarily the same length. I'll collect them whenever they are turned in, but the best practice is that they will be done by the next lecture. If I misgauge the time it takes to do a problem, please limit your time expenditure (no more than an hour on any assignment, and 1.5 hours total a week), and turn in the partially completed assignment for full credit. I want to encourage everyone to do their exercises, but with the assurance that this should be stress-free and bounded.

By default, graduate students will get a A-. Students who do a reasonable fraction of the homeworks will get an A, and students who do more will get an A+. A grade of B+ might be granted in the event of too many unexcused absences. There are no tests.

Prerequisite: Either 600 Algebra or Topology sequence. Note: Familiarity with both sequences will help.

Learning Outcomes: The goal of this course is to cover the standard material in a homological algebra course. Specific goals are to understand and be able to use the following concepts.

(1) Abelian and additive categories.
(2) Chain complexes, homotopies, and the homotopy category.
(3) Derived functors.
(4) Yoneda ext and its ring structure.
(5) Homological dimension. Koszul complexes.
(6) Spectral sequences.
(7) Triangulated categories. The derived category.

In addition, I hope to cover the following additional topics, time permitting.

(1) t-structures, cores, and homological functors.
(2) Grothendieck groups.
(3) Morita equivalence, and other ways to approach abelian categories.
(4) A brief introduction to Khovanov-Qi's Hopfological algebra.

Learning Environment: The University of Oregon strives for inclusive learning environments. Please notify me if the instruction or design of this course results in disability-related barriers to your participation.

Academic Conduct: The code of student conduct and community standards is at:

`http://conduct.uoregon.edu`

Any type of academic dishonesty will not be tolerated.

As is typical in mathematics, students are encouraged to work together on homework, but should prepare their written answers independently.

Office hours: I am stuck in my office, waiting to answer your questions, so please use the opportunity!

Please, do not hesitate to ask questions, either in class or in office hours. Chances are that if you are confused, so are many of your colleagues, and they will thank you for speaking up. Office hours should be very helpful. If you can't make office hours, email me to set up an appointment.

OUTLINE:

Week 1: Introduction. Baby representation theory: simples and indecomposables. Quiver representations - a nice playground.

Week 2: Projective objects and projective resolutions. Cones, Gaussian elimination, and other basic tools in homological algebra.

Week 3: Interlude: additive and abelian categories in the abstract. Diagram chasing without elements.

Week 4: Derived functors.

Week 5: Adaptedness. Homological dimension. Frobenius algebras.

Week 6: Koszul complexes. Yoneda ext.

Week 7: Spectral sequences

Week 8: Triangulated categories and derived categories

Week 9: Hopfological algebra

Week 10: I'm expecting the above to take 10 weeks, but who knows where the divisions truly lie.