PHYS 5040
Algebra and Topology in Physics
Spring 2021

OVERVIEW

This is an introductory course in group theory, representation theory, and algebraic topology for physicists. The primary focus of this class is the conceptual understanding of the mathematics, together with applications. This is *not* a formal course in mathematics; we will not prove all main results.

Lectures: Tu/Th 9:35-10:50 AM, on Zoom (links on Canvas)

Instructor: Andrew Lucas (`andrew.j.lucas@colorado.edu`).
Office hours: Su: 6:00-7:00 PM, M: 4:00-5:00 PM

Website: https://sites.google.com/colorado.edu/andrew-lucas/teaching/p5040s2021

Canvas: https://canvas.colorado.edu/courses/68644

Books: Not required, but strongly recommended for background reading:

- M. Nakahara. *Geometry, Topology and Physics* (2^{nd} ed., Taylor & Francis, 2003)
- A. Zee. *Group Theory in a Nutshell for Physicists* (Princeton University Press, 2016)

Recommended Prerequisites: Completed an undergraduate sequence in Lagrangian and Hamiltonian mechanics, quantum mechanics and electrodynamics. A course in differential geometry or general relativity would be a useful (but not required) corequisite.

Cross Lists: This course is also listed as MATH 5040.

COURSE OUTLINE

1:	Groups	(Zee I.1, I.2)
2:	Group representations	(Zee II.1, II.2, II.3, III.1)
3:	Lie groups and Lie algebras	(Zee I.3, IV.1, IV.2, IV.3, IV.4,IV.i1, IV.i2)
4:	Topological spaces	(Nakahara 2.3, 2.4, 3.2)
5:	Manifolds	(Nakahara 5.1, 5.2, 5.4, 5.5, 6.1.2)
6:	The fundamental group	(Nakahara 4.1-4.4)
7:	Higher homotopy groups	(Nakahara 4.5-4.10)
8:	Homology	(Nakahara 3.3, 3.4)
9:	Cohomology	(Nakahara 6.1.1, 6.2-6.4)

UNIVERSITY POLICIES

Standard university policies regarding appropriate conduct on campus also apply to this class, and can be found in writing on the course website.

GRADES

- **65% homework:** Homework can be found on the course website, and on Canvas. Homework is **due at or before 11:59 PM on the due date**. Solutions will be posted on the website on the third day after the due date. You must upload every homework assignment electronically into Canvas. You should anticipate about 14 homework assignments (1 per week).

  Homework late and drop policies: Every student has 3 extensions, which can be tracked in the ungraded "Extensions Left" assignment in Canvas. Extensions can be used as follows:

  - To receive a no penalty 48 hour extension on the due date for a homework assignment.
  - To drop a homework which was not turned in.
  - To drop a low homework score. (Any remaining extensions will be used this way at the end of the class.)

  I will not grant further extensions or push back deadlines any further (barring a common conflict among lots of students – let me know if this is the case). I will also apply these rules automatically, in order listed above, so you do not need to ask for permission to use these extensions.

  You can work together on homework, but you must write up your own solutions to receive credit for them.

- **35% exam:** During finals week, there will be a take home exam from 12:00 PM on May 1 to 11:59 PM on May 4. You may use any books or online references, but **must cite** all references you used (outside of course materials and assigned books). You **must work alone**, and **may not ask for help from any person** online or offline.

  You must turn in your exam on time. No extensions/drops are allowed on the exam.

The curve in this class is expected to be as follows (and will not be made harsher):

grade:	A	A–	B+	B	B–	C+	C	C–
% required:	85%	80%	75%	70%	65%	60%	55%	50%

The holistic grading method for this class can be found on the course website. Partial credit is assigned on the basis of the entire (sub)problem taken together, and is primarily given based on demonstrated conceptual understanding. Note that you can get full credit even with minor mistakes.

Each assignment will be graded out of 100 points. The numbers besides each (sub)problem denote the number of points that problem is worth. Note that, per the course's holistic grading scheme (which can be found on the course website), this number of points will always be a multiple of 5. In general, however, there will be more than 100 points that can be earned. Extra credit (scores over 100) are possible. You should expect that some of the problems on homework will be very hard, which is why you do not need to solve them to get "full credit" of 100 points. With that said, you should also at least try each problem – partial extra credit is assigned.