

Faculty of Science Course Syllabus
Department of MATH
MATH 4135
Intro to Category Theory
Fall 2017

Instructor(s): *Dorette Pronk* *pronkd@dal.ca* *Chase 302*

Lectures: *MWF 10:30-11:30* *Chase 319*

Course Description

Categories, functors, natural transformations and adjointness are introduced with emphasis on examples drawn from undergraduate Mathematics and theoretical Computer Science. The calculus of diagram chasing, limits, colimits and Kan extensions is explored in detail.

Course Prerequisites

MATH 3031.03 and MATH 3501.03 or permission of the instructor.

Course Objectives/Learning Outcomes

- Know the definitions of and be able to determine examples in a given category of special types of arrows such as epimorphisms, monomorphisms, retractions, sections and idempotents.
- Know the concepts of functor and natural transformation and know how to compose natural transformations both horizontally and vertically.
- Be able to perform certain basic operations on categories such as taking slices and comma categories.
- Know the three different descriptions of adjunctions and be familiar with several well-known examples such as free left adjoints, and the product-exponent adjunctions.
- Know what representable functors are, be able to prove the Yoneda lemma and derive its consequences such as the fact that the Yoneda embedding is full and faithful.
- Be able to work with the universal properties for limits and colimits and know some of the more familiar small limits and colimits such as (co)products, pullbacks/pushouts and (co)equalizers.
- Know the results about the relationships between representable functors and limits/colimits as well as left/right adjoint functors and limits/colimits.
- Know and be able to prove the general adjoint functor theorem.
- Know the concept of a monad and the two canonical ways it can be factored as an adjunction: through the Kleisli category and the Eilenberg-Moore algebras.

Course Materials

- Steve Awodey, *Category Theory*, 2nd Edition, Oxford University Press, 2011

- Useful lecture notes from other instructors may be found at <http://pages.cpsc.ucalgary.ca/~robin/class/617/webnotes.html>
- Brightspace website

Course Assessment

Component	Weight (% of final grade)	Date
Midterm	20%	October 24, 8:30 – 10:00
Final exam	40%	To be determined by the class
Assignments	40%	Weekly

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D	(50-54)
A (85-89)	B (73-76)	C (60-64)	F	(<50)
A- (80-84)	B- (70-72)	C- (55-59)		

Course Policies

- There will be weekly assignments, which will be due on Thursday of the next week at 5 PM in my office, or the next Friday morning by 10 AM at the latest. In general, I don't accept late assignments since I like to return graded homework on Tuesday.
- You are allowed to discuss your work with your class mates when solving the assignment problems, but you are required to do your final write-up by yourself.
- This course will only be cancelled in relation to weather related emergencies when the university is officially closed. If homework was due on that date it will be due on the date of the next scheduled class for this course.
- It will not be possible to write the final exam early and there will only be a make-up of the final exam in case of illness or family emergencies. So do not schedule your flight home before the final exam date.
- My office hours are Monday 10-11 AM, Wednesday 4-5 PM, Thursday 11:30-12:30.

Course Content

- Week 1 (September 5 & 7): Sections 1.1-1.6 Categories and functors – some basic properties and constructions
- Week 2 (September 12 & 14): Sections 1.7, 2.1-2.5 Free categories, properties of arrows, generalized elements, initial and terminal objects and products.
- Week 3 (September 19 & 21): Sections 2.6, 2.7, 3.1-3.4 Categories with products, Hom-sets, duality, coproducts, equalizers and coequalizers
- Week 4 (September 26 & 28): Sections 5.1-5.6 Subobjects, Pullbacks, Limits and Colimits

- Week 5 (October 3 & 5): Sections 6.1-6.3, 7.1-7.3 Exponentials, Cartesian closedness and Heyting algebras, the category of categories and representability
 - Week 6 (October 10 & 12): Sections 7.4-7.7, Stone duality, naturality and exponentials of categories
 - Week 7 (October 17 & 19): Sections 7.9, 7.10, 8.1-8.3 Equivalence of categories, presheaf categories, Yoneda
 - Week 8 (October 24 & 26): midterm and Sections 8.4 and 8.5 Applications of Yoneda and limits in categories of diagrams
 - Week 9 (October 31 & November 2): Sections 8.6, 8.7, 9.1, 9.2 Colimits and exponentials in categories of diagrams and adjoint functors
 - Week 10 (November 14 & 16): Section 9.3, 9.8, 10.1 and 10.2 Examples of adjoints and the general adjoint functor theorem, monads
 - Week 11 (November 21 & 23): Sections 10.1-10.4 Algebras for a monad and comonads with coalgebras
 - Week 12 (November 28 & 30): Student Presentations
-

University Policies and Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).

Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and

informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.

Code: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness.

Statement: <http://www.dal.ca/cultureofrespect.html>

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) (elders@dal.ca).

Information: https://www.dal.ca/campus_life/communities/indigenous.html

Important Dates in the Academic Year (including add/drop dates)

https://www.dal.ca/academics/important_dates.html

University Grading Practices

https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Student Resources and Support

Advising

General Advising https://www.dal.ca/campus_life/academic-support/advising.html

Science Program Advisors: <https://www.dal.ca/faculty/science/current-students/academic-advising.html>

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Black Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre/current-students.html

Academic supports

Library: <https://libraries.dal.ca/>



Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Studying for Success: https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Copyright Office: <https://libraries.dal.ca/services/copyright-office.html>

Fair Dealing Guidelines <https://libraries.dal.ca/services/copyright-office/fair-dealing.html>

Other supports and services

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness/services-support/student-health-and-wellness.html

Student Advocacy: <https://dsu.ca/dsas>

Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html

Safety

Research Lab Safety

https://www.dal.ca/content/dam/dalhousie/pdf/dept/safety/lab_policy_manual_2007.pdf

Biosafety: <https://www.dal.ca/dept/safety/programs-services/biosafety.html>

Chemical Safety: <https://www.dal.ca/dept/safety/programs-services/chemical-safety.html>

Radiation Safety: <https://www.dal.ca/dept/safety/programs-services/radiation-safety.html>

Scent-Free Program: <https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html>

(Please note that your instructor is allergic to scented products such as perfume and aftershave. Please avoid wearing these products to class or to office hours.)