

# Course Outline

COMP 546      Computational Perception

Winter 2025

Tues./Thurs. 10:05 AM – 11:25 AM      ENGTR 2120

Instructor:                    Michael Langer  
Office:                         McConnell Engineering 329  
Email:                         michael.langer@mcgill.ca (but see email policy in Sec. 5.3)  
Office Hours:                 Tues/Thurs (after class) or by appointment

## Teaching Assistants

The T.A.s are Venissa Carol Quadros and Marina Zhou. They will help out mostly with the assignments. Their office hours and contacts will be posted on the Discussion Board.

## 1 Overview

This course examines fundamental computational problems in visual and auditory perception. Unlike traditional perception courses in Psychology or Physiology departments which emphasize neural mechanisms, this course emphasizes *computational* aspects of perception.

For both vision and audition, we examine the sensory signals (images) from the environment, and the information that is contained in these signals. For vision, we examine luminance and color, defocus, binocular disparity, and motion information. For audition, we examine the spatiotemporal and frequency properties of sound and binaural timing and intensity differences between the ears. Using linear system theory, we model how such images are processed by the visual and auditory systems. For vision, we model how images are filtered into orientation, motion, and disparity selective channels. For audition, we model how sound waves are encoded into frequency channels and how interaural differences are computed and represented. Finally we consider how properties of the environment can be inferred from these computed representations. For vision, we consider how depth and 3D position are estimated and for audition we consider how depth and direction of sources are estimated.

The course does not require any background in vision or audition. That said, we will go relatively quickly so having some background would help.

Below is a more detailed breakdown of the course topics. Each of the topics will take 1-2 lectures.

## Vision (9 weeks)

- **image projection:** visual angle and direction
- **focus:** thin lens equation, depth of field, accommodation
- **photoreceptors, color:** spectra, metamers, color displays, color blindness
- **retina:** neural coding, spikes, DOG models, cross-correlation & convolution
- **orientation and V1:** simple and complex cells, retinotopic maps, Gabor models, contour and texture, multiscale analysis, sparseness
- **binocular disparity:** depth, disparity space, accommodation-vergence conflict, disparity tuned cells
- **image motion:** motion constraint equation; normal velocities, motion tuned cells
- **egomotion, eye movements:** motion parallax, VOR, smooth pursuit, saccades & attention
- **psychophysics:** psychometric curves, thresholds, JNDs, Weber's Law
- **peripheral vision:** crowding, texture metamers
- **perceptual organization:** Gestalt grouping, figure-ground, T and L junctions, contour grouping
- **occlusions and transparency:** half-occlusions in stereopsis, accretion-deletion in motion, occlusions and blur, X junctions
- **illumination and reflectance:** intrinsic images, lightness and color constancy

## Audition (3 weeks)

- **linear systems:** impulse functions, complex numbers, Fourier transforms, convolution theorem, filtering and bandwidth
- **sound sources:** speech, music
- **sound propagation:** head related impulse response
- **auditory coding:** filtering, source localization (duplex theory)
- **echolocation:** bats, CF vs. FM
- **pitch perception**

## 2 Prerequisites

There are no *official* prerequisites for the course, but I do expect the following background.

- computer programming: the assignments will use Python or Matlab. So, if you don't know one of these languages, then you will need to learn.
- multivariable calculus (MATH 222) e.g. partial derivatives, polar & spherical coordinates
- linear algebra and geometry e.g. vector spaces, matrices, eigenvectors, complex variables (MATH 133 minimum, MATH 223 would be nice)
- probability and statistics (MATH 203 minimum)
- waves and optics (PHYS 101 minimum)

No prior knowledge of psychology or physiology of vision and audition is expected.

## 3 Course Materials

Materials will consist of slides, lecture notes, and exercises all available on mycourses.

These materials are protected by copyright, please do not post these materials on github, coursehero, any other websites.

## 4 Evaluation

Your final course grade will consist of the following components.

### Four Assignments ( $4 \times 10\% = 40\%$ )

As mentioned above, the assignments will be done in Python or Matlab.

- A1 will be posted by January 23. It will cover basic models of retinal image processing, namely models of center-surround cells.
- A2 will be posted by February 13. It will cover orientation selection and binocular disparity.
- A3 will be posted by February 27. It will cover image motion, and psychophysics.
- A4 will be posted by March 27. It will cover linear systems and audition.

You will be given approximately two weeks to do each of the four Assignments. If you do not do an Assignment, then you will receive a grade of 0 for it. Extensions can be given only for unforeseen reasons, such as illness.

## Quizzes (0-18 %)

There will be six quizzes, each worth 3%. The quizzes are meant to encourage you to keep up with the course material.

You can replace the percentage grade for any quiz with your final exam grade. In that sense, the quizzes are optional.

Quizzes will be posted on Thursdays and will be due on Mondays.

- Quiz 1 – due Jan. 20 – covering lectures 1-3
- Quiz 2 – due Feb. 3 – covering lectures 4-7
- Quiz 3 – due Feb. 17 – covering lectures 8-11
- Quiz 4 – due Mar. 10 – covering lectures 12-15
- Quiz 5 – due Mar. 24 – covering lectures 16-19
- Quiz 6 – due Apr. 9 – covering lectures 20-23

The quiz questions will be a mix of multiple choice, multiselect, and short answer. *They will be done online on mycourses.*

Since the quizzes are online, they are “open book”. But you must do them entirely on your own. No communication is allowed between students about the quiz questions until the quiz is due.

## Final Exam (42-60 %)

The Final Exam will be held during Final Examination Period.

It will be worth anywhere from 42% to 60%, depending on your quiz grades.

The final exam will be *closed book*. No crib sheet or electronic devices are permitted. It will contain a mix of short and long answer questions. It will cover the material from the lectures, exercises, and assignments.

## McGill policy on the Evaluation scheme

As stated in Article 3.2.3, of the student assessment policy:

[https://www.mcgill.ca/secretariat/files/secretariat/2016-04\\_student\\_assessment\\_policy.pdf](https://www.mcgill.ca/secretariat/files/secretariat/2016-04_student_assessment_policy.pdf)

*“In the event of extraordinary circumstances beyond the University’s control, the evaluation scheme in a Course is subject to change, provided that there be timely communications to the students regarding the change.”*

## 4.1 Calculation of final course grade

There are many factors that determine your final grade, including how hard you work, how talented you are in this subject, how much time you devote to the course, what your academic background is, what your health or family situation is, etc. However, these factors will not be considered when calculating your final course grade. Rather, your grade will be determined entirely by the above grading scheme.

Your final course grade will be rounded off to the nearest integer. If you have a grade of 84.4 then it rounds to 84 and you get an A-, whereas if it is 84.6 then it rounds to 85 and you get an A. If one's grade is 84.5, it will round it up to 85. The same rounding procedure holds for low grades. If one's final course grade is 49.4 then it rounds to 49 which is an F. A very hard line is drawn here, so one does not want to fail then one should stay far away from that line.

McGill graduate students need a grade of 65 to pass.

## 4.2 Regrades

If you wish the instructor or the TAs to re-grade a question on an assignment or exam, we will do so. However, keep in mind that we reserve the right to re-grade other questions as well.

## 4.3 Additional Work

You will *not* be given the opportunity to do additional work to upgrade your grade.

## 4.4 Supplemental/Deferred Exam

The Supplemental/Deferred Exam exam will cover the same material as the Final Exam and will replace the Final Exam grade. The same “max” rule for quizzes and final exam will apply.

For information on Supplemental Exams, see

<https://www.mcgill.ca/science/student/general/exams/supplemental>.

# 5 Communication Policies

## 5.1 Course Announcements

Important information about the course will be announced in class, or on the Ed Discussion board.

## 5.2 Getting help from the instructor (me) or a T.A.

If you have a technical question about the course material or an assignment, *do not email me*. Instead:

- If it is an assignment question, then see a T.A. during their office hours, or post your question on the Ed Discussion board. There is a private setting in case you do not wish other students to see your post. There is also an anonymous setting and you wish only me and the TA's to see it.
- If it is a question about a quiz or lecture material, then post your question on Ed. (See Discussion Board policies below.) I will do my best to answer your question within 24 hours.

## 5.3 Instructor email policy

I am notified whenever there is a post on Ed, so the only reason to email me rather posting on Ed is if you do not wish the TA's to see your post, for example, if you have an urgent and important *personal* matter.

You can email one of the TA's for matters that are entirely between you, e.g. following up on a correspondence or arranging for a meeting outside of office hours.

## 5.4 Ed Discussion Board Guidelines

I will moderate the Discussion Board, with some help from T.A.s for assignment questions. We also strongly encourage you to help each other out by responding to posts. Guidelines for posting on the Discussion Board are as follows.

- Use the search feature to check if your question has been asked before.
- Choose an appropriate subject line.
- If you have multiple questions that are unrelated, then use multiple postings. Otherwise the threads become too entangled.

## 5.5 McGill language policy

*In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.*

[https://www.mcgill.ca/study/2017-2018/university\\_regulations\\_and\\_resources/undergraduate/gi\\_lang\\_policy](https://www.mcgill.ca/study/2017-2018/university_regulations_and_resources/undergraduate/gi_lang_policy)

## 6 Academic Integrity

### 6.1 Collaboration on assignments and plagiarism

We encourage you to discuss the assignment problems with each other, and to help each other out with debugging. *However, there are limits to your collaboration.* Your discussions should not go so far that you are revealing the solutions to each other, and you must *never copy code* from each other. Any cases of suspected plagiarism will be reported to the Faculty of Science Disciplinary Office.

### 6.2 McGill policy on academic integrity

*McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offenses under the Code of Student Conduct and Disciplinary Procedures. See <http://www.mcgill.ca/students/srr/honest/> for more information.*