

# Course Outline

Computational Perception

COMP 546

Fall 2022

Tues./Thurs. 1:05 PM – 2:25 PM

ENGTR 1100

Instructor: Michael Langer  
Office: McConnell Engineering 329  
Email: langer@cim.mcgill.ca  
Office Hours: Tues/Thurs (after class) 3 PM – 3:30 PM or by appointment

## Teaching Assistants

The T.A.s are Julie Alhosh and Tudor Sintu. They will help out mostly with the assignments. Their office hours and contacts will be posted on the assignment PDFs.

## 1 Overview

This course examines fundamental computational problems in visual and auditory perception. Unlike traditional perception courses offered in Psychology or Physiology departments which emphasize neural mechanisms, this course emphasizes *computational* aspects of perception. Our two main topics are vision and audition.

We examine the sensory signals from the environment, namely visual and auditory images, and the information that is contained in these images. For vision, we consider luminance and color, defocus, binocular disparity, and motion. For audition, we consider the spatiotemporal and frequency properties of sound and binaural timing and intensity differences between the ears.

We examine how images are processed by the visual and auditory systems, using concepts and tools from linear system theory. For vision, we discuss how space-time images are filtered into orientation, motion, and disparity selective channels and how these channels can be combined. For audition, we discuss how sound waves are encoded into frequency bands and how interaural differences are computed.

We then examine how properties of the environment can be inferred from the information that is extracted from images. For vision, we consider how depth and spatial position are estimated from motion, blur, disparity, and head position (vestibular) information. We will also cover topics such as perceptual organization, attention, and object and scene recognition. We will examine trends in computational models of vision, including (briefly) recent models based on deep learning. For audition, we consider how depth and direction of sources are estimated.

The course content will consist mostly of lectures. There will also be poster sessions in the last few lecture slots of the course, where students will present and discuss research papers that they have read.

## 2 Course Materials

The materials will consist of a slides, lecture notes, and exercises which will be made available on mycourses. There is no course textbook.

The lectures will cover the following topics:

- Vision
  - geometry
  - focus and blur
  - photoreceptors, color
  - retina
  - orientation
  - binocular disparity
  - image motion
  - egomotion and eye movements
  - psychophysics
  - perceptual organization
  - illumination and reflectance, transparency
  - shape, material
  - attention
  - object and scene recognition
- Audition
  - linear systems & Fourier transform
  - sources of sound (speech, music)
  - sound propagation : head and ear
  - auditory coding, source localization

## 3 Prerequisites

There are no official prerequisites for the course. It is assumed students can program in a high level language at least that level of COMP 250 and are comfortable with basic mathematics needed for a B.Sc. in particular:

- Calculus 2 (at least). Some multivariable calculus would be good (MATH 222)
- basic linear algebra and geometry - e.g. vector spaces, matrices, complex numbers
- probability (normal/Gaussian distributions and definitions such as mean and variance).
- waves and optics (CEGEP level or PHYS 101/102).

The course will cover some basic psychology and physiology of vision and audition. It will also cover basic tools of linear system theory (convolution, Fourier transforms). No prior knowledge of these topics is assumed.

## 4 Evaluation

You will be evaluated based on the following.

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

The assignments will involve Matlab programming. You are not required to know Matlab prior to the course.

- A1 will be posted in mid-September. The topic will be basic stereo geometry and retinal image processing namely models of center-surround cells.
- A2 will be posted in early October. The topic will be early visual processing: orientation selection, binocular disparity, and motion.
- A3 will be posted in mid October. The topic will be color perception.
- A4 will be posted in mid-November. The topic will be linear systems theory (Fourier transforms) and sound analysis using spectrograms.

You will be given approximately two weeks to do each of the three 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. The instructor reserves the right to ask for documentation.

### Research Poster Presentation (15%)

In the last few scheduled class slots (end of November and start of December), we will have poster presentations of research papers that you have read. You will most likely work in teams of two. (This will depend on how many students are in the course at end of Add/Drop period.) You will be given a list of papers to choose from. You will read the paper, discuss it with your partner, write up a summary of the paper, and present it in a poster session. *A detailed PDF on the requirements and logistics will be posted in October.* You will do the bulk of the work in the first two weeks of November, between Assignments 3 and 4.

## Quizzes (0% or 10%)

There will be three quizzes. Their purpose is to encourage you to keep up with the lectures.

The planned dates are: [Updated Sept 23: I had originally listed the lecture number ranges as 2-7, 8-14, 15-20, corresponding to the intro being lecture 1]

- Quiz 1 – Sept. 26 covering lectures 1-6
- Quiz 2 – Oct. 24 covering lectures 7-13
- Quiz 3 – Nov. 21 covering lectures 14-19

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

Since the quizzes are online, they are “open book”. You must do them entirely on your own. No communication is allowed between students about the quiz on the day of the quiz.

You will be given one hour, namely any one hour interval you wish from 8 AM to 10 PM. If you are registered with OSD and need more time than that, then you will need to let me know at least one week in advance.

I will count your best two out of the three quizzes, so each is worth 5% of your final grade.

The quizzes are optional: if your percentage grade on the final exam is better than your percentage grade on your best two quizzes then your final exam grade will count more – see below.

## Final Exam (35% or 45%)

The Final Exam will be held during Final Examination Period.

It will be worth either 35% or 45%, depending on whether your percentage grade on the final exam is less than or greater than your quizzes (best 2 of 3) percentage grade, respectively.

The final exam will be *closed book*. No crib sheet or electronic devices are permitted.

The final exam will contain a mix of multiple choice questions and short answer questions.

## 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.”*

## 5 Miscellaneous Policies

### 5.1 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 one has a grade of 84.4 then it rounds to 84 and one gets an A-, whereas if it is 84.6 then it rounds to 85 and one gets an A. If one's grade is 84.5, it will round it up to 85. The same round off 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. (Note that grad students need a 65 to pass.)

### 5.2 Regrading

Mistakes can occur when grading assignments or exams. Not surprisingly, requests for re-grading are always in situations in which students feel they received fewer points than deserved, rather than more points than deserved. With that upward tendency in mind, please note that if you wish the instructor or the TAs to re-grade a question on an assignment or exam, we will do so. However, to avoid upward grade ratcheting, *we reserve the right to re-grade other questions as well.*

### 5.3 Additional Work

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

### 5.4 Collaboration on assignments and plagiarism

We encourage you to discuss the assignment problems with each other, and to help each other out with debugging. We also encourage you to use the mycourses Discussion Boards. *However, there are limits to your collaboration.* You can give hints to each other, and the TAs and instructors will give hints sometimes if you ask. However, the hints and discussion 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.

### 5.5 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>.

## 5.6 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)

## 5.7 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*