

# Course structure for the University of Rochester's Hybrid Optics Masters Education (HOME) Program

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## ABSTRACT

The Institute of Optics at the University of Rochester (UofR) launched a new program in the Fall of 2020 for students interested in earning an MS in optics. The program is referred to as the Hybrid Optics Masters Education, or HOME. The HOME system of coursework allows working individuals to take classes remotely either synchronously with in-person MS students through Zoom, or asynchronously guided by the professor. Courses are structured to be inclusive to the online learner through group projects and discussion with other in-person/online students, and one-on-one interaction with the professor and teaching assistant. Each course has specific learning objectives and may incorporate a variety of technology platforms to engage the student, and create an active learning environment. The degree requirements for the MS HOME and in-person Optics MS are identical, only the form of curriculum delivery has been modified. Optics faculty were enrolled in a specific course through the UofR's Warner School of Education to develop their online curriculum. Detailed information about requirements for the degree, as well as layout, tools, and other relevant resources used will be shared in this paper.

**Keywords:** Online learning, Optics curriculum, Masters degree, graduate education, technology platforms

## 1. INTRODUCTION

The Institute of Optics at the University of Rochester (UofR) had experimented with graduate online teaching back in 2011 when a class, *Advanced Optical Interference Coatings*,<sup>1</sup> was taught simultaneously at the UofR as OPT 447, and the University of Arizona (UofA) as OPTI 577. At that time, synchronous lectures could be viewed by students online or in-person but only using presentation slides and recorded through applications such as GoToMeeting™. The lecture recordings were uploaded to Blackboard (UofR) or MyCourses (UofA), and all students could view the hour-long lecture asynchronously if necessary. There wasn't a way to view the professor or any of the in-person or remote students with a webcam. Meeting technology was cumbersome at that time, and many of the in-person students complained about the length of time it took from each lecture to get connected to the meeting platform and start recording. Compiling the video recording took almost as long as the actual lecture, and it doubled the workload for the professor. The UofR wasn't interested in investing in online learning back then, and the course returned to in-person only.

Fast forward to the spring of 2019, and The Institute wanted to try again to offer graduate courses online. The Warner School of Education at the UofR was offering courses to their graduate students to prepare them for online teaching. The Institute faculty were invited to take part in these courses, and many of the faculty registered to take one course taught by Dr. Eric Frederickson, *Topics in Online Learning*,<sup>2</sup> starting in May of 2020. It is said that "timing is everything," and due to every University in the US going to remote learning in the fall of 2020, the Institute was extremely prepared as we rolled out our new Hybrid Optics Masters Education (HOME) program to our Masters students on a global scale that semester.

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## 2. ONLINE LEARNING COURSE COMPONENTS

One of the textbooks we used in Dr. Frederickson's class was by Thornmann and Zimmerman.<sup>3</sup> This text gave suggestions on how to structure Learning Management Systems (LMS), like Blackboard, to create an organized and seamless layout that encompasses a course from beginning to end. Creating the layout of a course, and populating all of the necessary elements can be labor intensive at first, but in the end will save time as a course is perpetuated from year to year.

### 2.1 Professor, Teaching Assistant, and Student Introductions

Online students need to feel connected to the rest of the in-person and online cohorts. Blackboard course pages will have photos and contact information for the professor and the teaching assistant(s). A valuable tool used for introduction of professor-to-student and student-to-student is a platform called VoiceThread.<sup>4</sup> VoiceThread allows the professor to record a video introduction that can be accessed by the students. The student would also record a video introduction. The professor could ask the students questions about themselves to answer in their short video, such as "What school did you attend as an undergraduate?", etc. Videos can be closed captioned for hearing impaired students. Each student can view the introductory videos of their classmates. Another benefit of using VoiceThread is the professor can learn the pronunciations of names and see the student's faces. Points for completing the videos go towards the student's overall grade to encourage students to participate.

### 2.2 Learning Objectives and Modules

We were prompted to categorize our courses into 4-8 main topics, or modules. For example, in the Color Technology course (OPT 422) there is a module for Additive Color Mixing and another for Subtractive Color Mixing. With each module comes a dedicated list of learning objectives, or outcomes, that each student should attain by the end of the module. We were discouraged from using vague terms such as, "the student will learn. . .," or "the student will understand. . .". Bloom's Taxonomy<sup>5,6</sup> was used to select descriptive verbs that were aligned with specific outcomes. For example, by the end of the Additive Color Mixing module the students would be able to:

1. Distinguish between rgb and xyz color matching functions
2. Prove Grassmann's Law for additive mixing
3. Compute 1931 CIE Chromaticity Coordinates
4. Evaluate the color gamut and color matching functions of a display

### 2.3 Assignments, a Checklist, and Grades...Oh my!

We were shown how important it was to create assignments (or at least have an idea what they would be) before the semester started. We had to decide how many homeworks, quizzes, exams, projects, or presentations in total would be assigned during the semester, where the sum of all points for each **added up to 100**. Students would be able to calculate their grades at any time during the semester. Percentage of an overall grade can be a source of confusion for students. If they know what points they have already earned, and how many there are to go, they will be able to figure out where they stand. An example from the course Optical Interference Coatings (OPT 446) can be found in Table 1.

Academic honesty is always a concern, especially with online courses. There are many ways to minimize cheating. Two simple strategies that we incorporated into our courses were: *low stakes* quizzes, and no single assignment *is ever worth more than 12* points. The quizzes are made to reinforce concepts learned in class in a way that builds confidence for the student. The quizzes are only worth one point so they are made to be relatively easy. Many LMS, like Blackboard, have quizzes that you can input directly as a 'test', randomize the questions, and link directly to the Grade Center. They can be timed, or they can be taken over the course of a week, but only taken once. There is more incentive to cheat if a single assignment at the end of the semester is worth a significant portion of the student's grade.

Another extremely important addition to our course components was an *Assignment Checklist*. This checklist has all of the assignments and due dates for the entire semester and is provided at the beginning of the course.

Table 1: Assignment Checklist from OPT 446  
- Optical Interference Coatings

| <u>Assignment</u>                  | <u>Points</u> |
|------------------------------------|---------------|
| Academic Honesty Quiz              | 1             |
| VoiceThread Introduction           | 2             |
| Homework $\times$ 8, 8 points each | 64            |
| Quizzes $\times$ 6, 1 point each   | 6             |
| Exams $\times$ 2, 10 points each   | 20            |
| <u>Group Project</u>               | <u>7</u>      |
| <b>Total</b>                       | <b>100</b>    |

In course evaluations over several semesters this one item was valued above all else. Students, especially those working full-time, are able to plan out the entire semester at once. The checklist for the first module in Color Technology (OPT 422) is shown in Figure 1.

Please print this out or save wherever you put important items for OPT 222/422. **All assignments are due by 11:59pm.**

| <b>Module</b>   | <b>Due Dates</b>   |
|---|--|
| <b>Module 1 – Color Matching Experiments and Additive Color Mixing</b><br><br>January 11–<br>February 12<br>(Weeks 1 - 4) | <input type="checkbox"/> Course Info Quiz (1/15)<br><input type="checkbox"/> Read Field Guide relevant pages<br><input type="checkbox"/> Follow Lecture Slides<br>-----Photronics West 1/30/23 – 2/3/23-----<br><input type="checkbox"/> Watch videos for slides 100 – 146<br><input type="checkbox"/> Complete Homework #1 (2/1)<br><input type="checkbox"/> Take Quiz #1 (2/5)<br>-----<br><input type="checkbox"/> Complete Homework #2 (2/8)<br><input type="checkbox"/> Take Quiz #2 (2/12) |

Figure 1: An example of the assignment, reading,<sup>7</sup> and video viewing activities required for Module 1 of OPT 422 - Color Technology.

## 2.4 Lecture Delivery

For many of the courses offered in the HOME or in-person MS program the professor does not have to record the synchronous class lecture in Zoom. The reason is that all of the lectures for the semester have already been pre-recorded, and they can be found in each module. We broke each lecture down into small video sections, referred to as *chunking*. No “chunk” is greater than 15 minutes. This way an asynchronous student (or even a synchronous student) can watch the videos whenever they can fit in a 10-15 minute section. If they do not understand the topic, they can easily go to the beginning. Sifting through an hour and a half lecture video to find the topic of confusion takes time.

The videos can be a recorded PowerPoint lecture, or written on a tablet or document camera. Some professors really enjoy writing on a blackboard, but many of the classroom cameras don’t capture the contrast of the text on the board adequately. The solution for us was to use a Lightboard.<sup>8</sup> Lectures can be written on a glass surface that has white light LEDs along the perimeter of the glass, inside the frame. When fluorescent whiteboard markers are used, they glow. The professor can write on the glass and be in the student’s view. A 45-degree mirror is placed in front of the camera to give the proper parity, so that the students can view the written text in the correct orientation. Lastly, the videos are embedded as thumbnails into Blackboard instead of a link. HTML can be used to give the location of the video file, and insert the video frame directly into a page in Blackboard. This way the students can see what a frame in the video looks like before they watch it. An example of a complex math review lecture written on a Lightboard is shown in Figure 2.

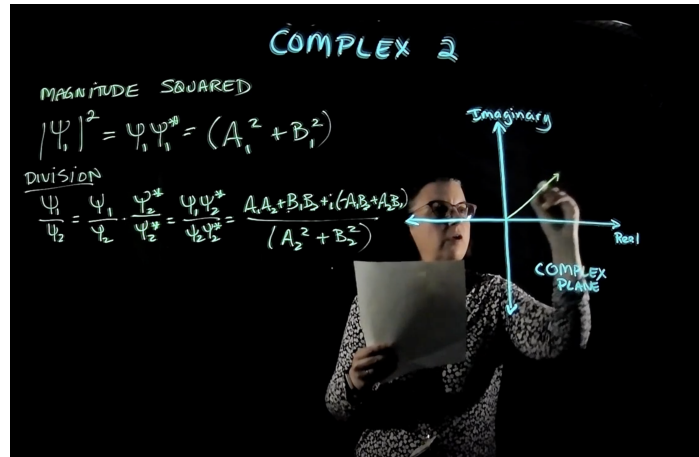


Figure 2: Complex math lecture video using a Lightboard.<sup>8</sup>

## 2.5 Group Projects and Presentations

An assignment strategy that helps to reinforce a topic in the classroom and increase the sense of community with the students is to group students together to work on a class project. A great collaborative technology platform for the students to display and review their projects to the class is called Padlet.<sup>9</sup> Padlet is an online bulletin board where students can organize their notes, graphics, images, etc., for other students to view. For engineering or scientific assignments where the students need to incorporate equations into their presentation, Padlet has an equation editor that works with L<sup>A</sup>T<sub>E</sub>X. An example of a group project presented on Padlet is from OPT 422 - Color Technology, where the group had to modify tiff images using a variety of International Color Consortium<sup>10</sup> (ICC) profiles within MATLAB (Figure 3).

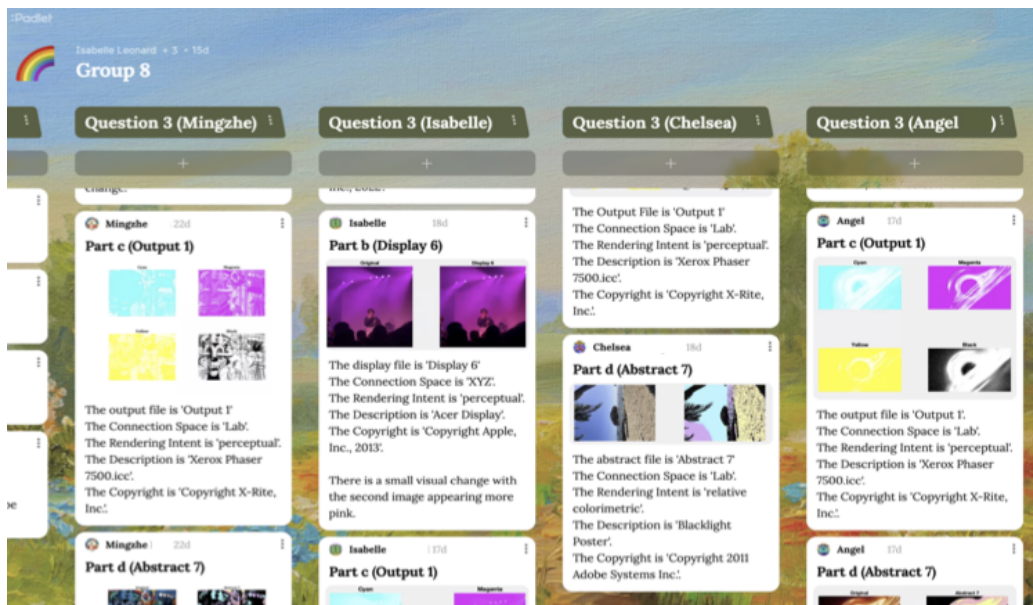


Figure 3: A group project for OPT 422 - Color Technology presented in Padlet. The project required the student group to alter images by changing the embedded ICC profiles using MATLAB.

### 3. THE OPTICS MS DEGREE REQUIREMENTS

The Institute’s MS program is divided up into two plans, A and B. In Plan A, the MS student writes a thesis while taking a few core courses. Plan B is the coursework only option. Currently the HOME program is aligned with Plan B. The Plan B option requires 30 credit hours of coursework and the completion of a 15-page literature review on a topic in optics or photonics that is of interest to the student. The courses are broken down by core (required) courses and technical electives. The core courses are the following:

- OPT 423 - Detection of Optical Radiation
- OPT 443 - Foundations in Modern Optical Systems (Geometrical Optics)
- OPT 463 - Wave Optics and Imaging (Physical Optics)
- OPT 456 [or 454] - MS Laboratory [or MS HOME Laboratory]

The students need to complete four additional elective courses, three of which must be in the areas of Geometrical Optics (e.g., OPT 444 - Lens Design), Physical Optics (e.g., OPT 446 - Optical Interference Coatings), and Quantum (e.g. OPT 465 - Lasers).

There is no difference in the graduate degree between the HOME program and the in-person MS program. HOME students are required to fulfill their laboratory core course in-person, at the University.

### 4. THE HOME IN-PERSON LABORATORY

The MS Laboratory (OPT 456) has been a requirement for the Optics MS program for several decades.<sup>11</sup> The lab experiments are extremely alignment intensive, and cover a broad range of topics. It is important that every MS student experience this laboratory, learn how to write a proper lab report, and present their data as they might at a conference or symposium. The HOME program has this lab requirement as well, but instead of a full 14-week semester, the lab is condensed into three weeks. There are several ways that a HOME student can come to campus to take the laboratory . OPT 454 (MS HOME Laboratory) is three continuous weeks during the summer at the University. We realize that some students may not be able to stay for three continuous weeks, so we divided OPT 454 into three individual weeks:

1. OPT 401 - MS HOME First Laboratory
2. OPT 402 - MS HOME Second Laboratory
3. OPT 403 - MS HOME Third Laboratory

OPT 401-403 are offered in the fall and spring semesters before classes start. They are also offered in succession at the same time as OPT 454 (see Table 2). OPT 401 is a prerequisite course for OPT 402 and 403.

Table 2: Different offerings for the in-person HOME laboratory.

|          | Spring   | Summer |        |        | Fall     |
|----------|----------|--------|--------|--------|----------|
| Course # | Variable | Week 1 | Week 2 | Week 3 | Variable |
| OPT 454  | --       | ✓      | ✓      | ✓      | --       |
| OPT 401  | ✓        | ✓      |        |        | ✓        |
| OPT 402  | ✓        |        | ✓      |        | ✓        |
| OPT 403  | ✓        |        |        | ✓      | ✓        |

There are lab experiments that take 12 hours to complete, and others 6 hours. The first week includes an alignment bootcamp to introduce the students to the types of activities they might experience in a lab, such as pinhole positioning in a spatial filter. Students are also trained to use oscilloscopes, spectrum analyzers, power meters, etc. The lab groups will each perform a 12-hour lab with a formal lab write up that is due by the end of the first week. The second and third weeks combine other 12-hour and 6-hour labs, where some labs require a formal lab write up, complete data sheets, or even giving a 20 minute presentation about the lab.

## 5. SUMMARY

The faculty at The Institute of Optics who teach for the MS program (both in-person and HOME) have devoted many hours developing their courses to be compatible with remote learning. We have incorporated easy to navigate websites, lecture videos that are simple to watch, assignment due dates on the first day of class, and technology platforms that are engaging and help to make all of our students feel a part of The Institute community. Our goal is to deliver a high-quality graduate education to those in and outside of the Rochester, NY area.

As our HOME students progress through the program, we have found that they are excited to come to campus to meet their professors and other in-person or HOME students they may have met in their hybrid courses. We will continue to provide different options that will make the lab experience more convenient for our HOME students. The Institute is invested in the HOME program, and we look forward to meeting working student's needs for many years to come.

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