

Optics for Engineers
EECE4646 — Spring 2017
Final Exam

Prof. Charles A. DiMarzio
Department of Electrical and Computer Engineering
Northeastern University

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Name: _____

General Instructions.

Schedule In fairness to all, I must insist on adhering strictly to the schedule. The exam is due Friday 28 April at 11:59:59. You can submit a good-quality .pdf. Please only submit a single file.

Please do not collaborate with other students or seek help from outside experts. However, you may use any reference book, journal articles, or other readily available resources. Please cite references if you do so.

Please contact me if you are confused about the wording of a problem. I will clarify the wording of the problems if I can do so without giving away the answer, or correct an error in the questions if someone should find one. Keep an eye on the announcements on the course web site for such updates.

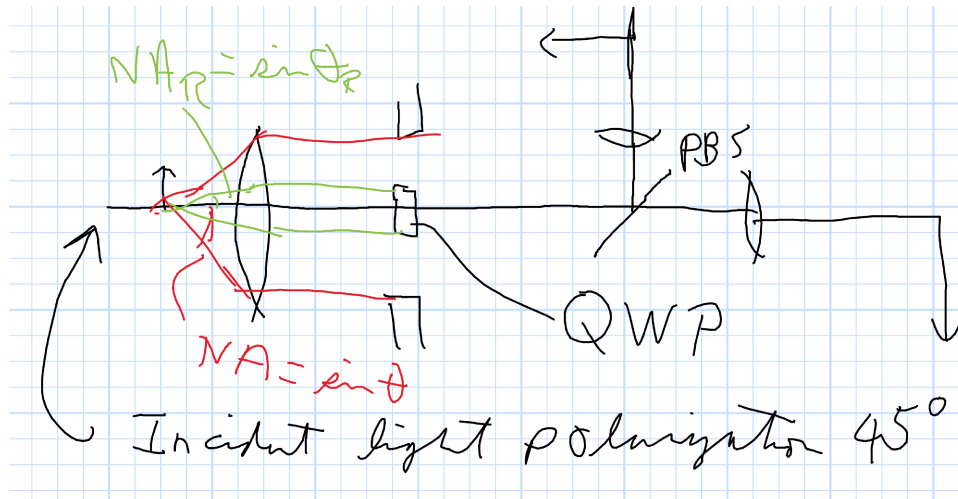
Draw a figure for each of the problems. Usually in my problems, the first step is to generate a layout of the optical system. I give points for figures.

You will want to use a computer for some of the problems. You may use any language you like, but make sure that the equations and graphs are presented in such a way that I don't need to look at your code. When I ask for a plot, I am looking for a correctly labeled one, with correct numerical values. A sketch is not sufficient.

Present your work as clearly as possible. I give partial credit if I can figure out that you know what you are doing. I do not give credit for putting down everything you know and hoping I will find something correct in it. In previous years, many students typeset the whole exam in Word or L^AT_EX, which made it easy to follow. These exams are usually the easiest to grade, particularly when I seek to understand the reasoning in order to assign partial credit.

1 Common Path Microscopy

We talked in class about a microscope using a Mach–Zehnder interferometer to obtain coherent images. One of the disadvantages was a lack of stability between the signal and reference arms, causing fringes to move in time. Here we investigate a common–path interferometer where we obtain the reference beam from a small portion of the signal in the pupil as shown in the figure below. To get you started, I will supply code to model a microscope, with a given numerical aperture, looking at a low–contrast transparent sphere.



Your goal is to modify the pupil transmission so that a small circle, slightly off-axis, has a transmission of j instead of 1. We could achieve this by placing a glass plate in the pupil with a quarter-wave layer of material in the required area.

Modify the given code to allow for this. Assume the center of the modified region of the pupil is at $(up,0)$.

First, show an image of the signal mixed with a tilted plane wave,

$$\text{abs}(E + \exp(1j * k * \sin(up) * x)) .^ 2.$$

Here it is ok if E is the original object field. We'll call this the ideal interferogram.

Then play with the parameters of your pupil and compare the resulting images with this ideal interferogram.

2 Radiometry

Let's explore the potential for providing daylight deep inside a building by transporting sunlight through an optical fiber. Suppose the fiber is 1 millimeter in diameter and has a numerical aperture of 0.4. Assume that I design

the best optical system to couple the sun into the fiber. How many watts can I pass through the fiber?