Midterm Exam
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EECE4646, Spring 2024
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Student Name: _____

1 Short–Answer Questions

Pick one answer for each problem, except as noted.
A lens with two convex surfaces (as seen from the air) has a positive focal length.

☒ True ☐ False

A planoconvex lens is used to collimate light from a point source so that it will focus at infinity. It is best to put the convex side toward the source

☐ True ☒ False

Light at a wavelength of 1.8 micrometers is
☐ Ultraviolet ☐ Visible ☒ Infrared

We make a 1:1 relay using a single lens with positive focal length, f. Check all true statements.
☒ $s = s'$
☒ $s = 2f$
☐ The image is upright
☐ A planoconvex lens is the best choice.

A photon of red light has more energy than a photon of blue light

☐ True ☒ False

A laser beam has a wavelength of 633 nm in vacuum. In glass

- ☐ The wavelength is the same as in vacuum.
- ☐ The wavelength is longer.
- ☒ The wavelength is shorter.

Valid units for irradiance are

☒ Watts/m^2 ☐ Joules/m^2 ☐ Watts/m^2/steradian

A photon detector usually has a more uniform response to power across different wavelengths. than a thermal detector

☐ True ☒ False

As the aperture diameter of an optical system increases,

- ☐ The diffraction limit becomes larger and aberrations become worse.
- ☐ The diffraction limit becomes larger and aberrations become better.
- ☒ The diffraction limit becomes smaller and aberrations become worse.
- ☐ The diffraction limit becomes smaller and aberrations become better.

The aperture stop limits the amount of light and the field stop limits the field of view.

☒ True ☐ False

Two perfect polarizers are crossed so no light is transmitted. A third is inserted between them at 45 degrees relative to the first. The transmission is

- ☐ $T = 1$.
- ☒ $T = 0.25$.
- ☐ $T = 0$.

Sunlight is viewed through a polarizer. The transmission is less than or equal to 0.5.

☒ True ☐ False

2 One Lens

Consider a single lens with a focal length of $f = 20\,\text{mm}$. We want to use it to make the largest possible image of a sheet of paper 8.5 inches by 11 inches on a camera that is 1 centimeter square with 1000 pixels in each direction.

a. What is the object distance?

$m = 1/(11 \times 2.54)$

$\frac{1}{m} = \frac{-s}{s'} = -s\left(\frac{1}{f} - \frac{1}{s}\right) = \frac{-s}{f} + 1$

$s = \left(1 - \frac{1}{m}\right) f$

579 mm

b. What is the image distance?

$\frac{1}{s'} = \frac{1}{f} - \frac{1}{s}$

20.71 mm

c. What is the size of a pixel on the paper?

$\text{Pixel} = \frac{10^{-2}\,\text{m}}{1000}$

0.279 mm

$\text{Pixel/m} =$

3 Two Lenses

A 10X microscope objective with a 0.5 Numerical Aperture is designed by the manufacturer to work with a tube lens of 200 mm.

a. What is the focal length of the objective?

$m = -\frac{f_2}{f_1}$ $f_1 = \frac{f_2}{m}$

20 mm

b. Where should the object be placed?

20 mm before objective

c. What is the size of the aperture stop?

$2 \tan(\arcsin(NA)) \times f_{obj}$

23 mm

d. I use the objective in a home–built microscope with a tube lens of $f_{tube} = 300$ mm. What is the magnification?

$\frac{f_2}{f_1}$

15 X

4 Polarization

A laser cavity contains a glass tube filled with gas including carbon dioxide to provide gain around 10.59 μm. The ends of the tube are sealed with Brewster windows made from Germanium ($n = 4$).
a. What is Brewster's Angle? Calculate it from an equation.

76 Degrees. $\tan\theta = \frac{n_2}{n_1}$

b. What are the transmissions for S and P polarization for a single surface from air to Germanium? You may estimate from the graph. Calculating one of these is a bit of work.

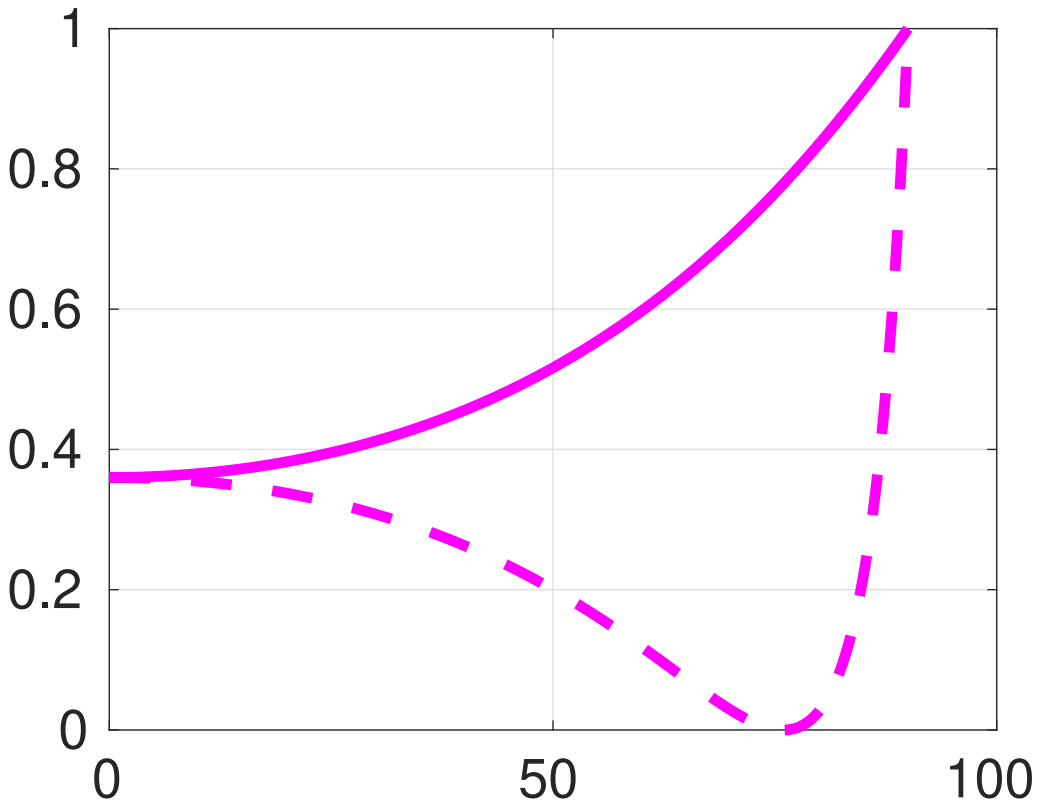
$T \approx 1 - R$

$T_P =$ 1 $T_S =$ 0.2

c. What is the round–trip transmission assuming that one mirror has $R_1 = 1.00$ reflection and the other has $R_2 = 0.70$?

4 surfaces 2 directions

$T_P =$ 1 $T_S =$ 2.6×10^{-8}


1
0.8
0.6
0.4
0.2
0
0
50
100