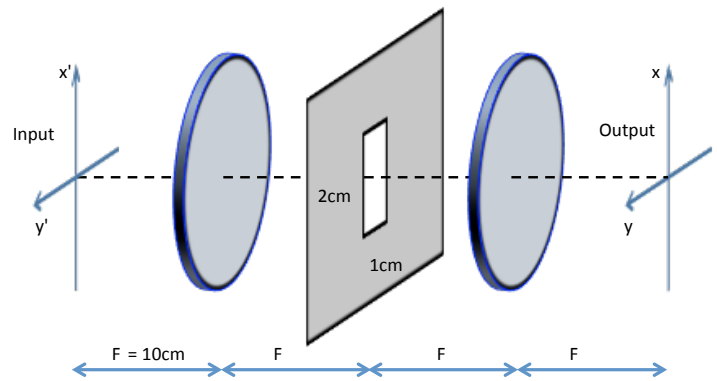


Photonics MS Exam Fall 2015

Question 1: Imaging & Diffraction

Part 1: A 4-F relay imaging system is made of two ideal 10cm focal length lenses, and 2 by 1 cm rectangular aperture, arranged as shown at right. The aperture is 100% transmissive within the rectangle, and opaque elsewhere. The input light is 500nm in wavelength. What is the functional dependence **of the impulse response**, and the **full widths δx and δy** (between zero intensity) of the spot?



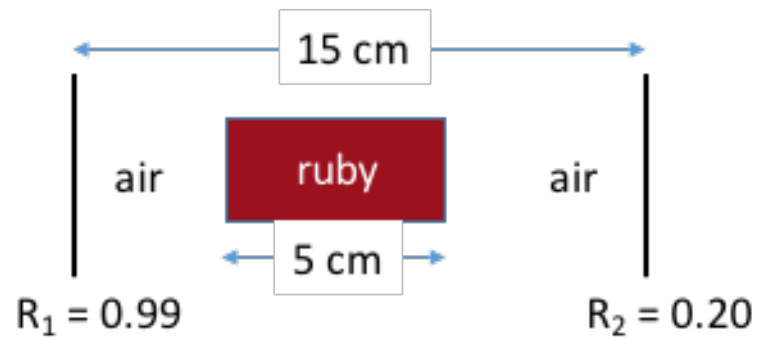
Part 2: A spatial filter has sinusoidally varying amplitude transmission ranging from zero to 1, with a spatial period of 10 microns. **Express $t(x)$ and provide the angular spectral decomposition** (angular spectra) of the transmitted wavefront when this filter is illuminated by an on-axis plane wave of wavelength 500nm.

Part 3: This spatial filter is placed in contact with the rectangular aperture in the system above. Without deriving an explicit expression for the overall system output, **calculate the spatial separation** between the outputs generated by the **minus first and first output orders** of the filter.

Photonics MS Exam SPR 2015

Question 2: Lasers

A crystal of ruby of length 5 cm and cross-sectional area 1 cm^2 is placed as shown between a highly-reflecting mirror (intensity reflection coefficient 0.99) and a weakly-reflecting mirror (intensity reflection coefficient 0.20). The distance between the mirrors is 15 cm.



Properties of Ruby: absorption coefficient is 0.5 /cm , refractive index is 1.8 at wavelength of 700 nm and when it is optically pumped, the spontaneous emission cross-section is $2.5 \times 10^{-20} \text{ /cm}^2$.

- What is the gain (units: /cm) needed to achieve lasing threshold? [2 points: 1 point for correct equation, 1 point for correct numerical value]
- How many Ruby atoms are population-inverted at lasing threshold? [3 points: 2 points for correct equation(s), 1 point for correct numerical value]
- What is the photon lifetime in the passive cavity? [3 points: 2 points for correct equation, 1 point for correct numerical solution]
- Assume that each of the population-inverted atoms emits a photon at 700 nm with uniform probability within the photon lifetime (calculated in part c). What is the output power of this laser? [2 points: 1 point for correct equation, 1 point for correct numerical value]