2.71

Quiz 2

50 min

8:05–8:55am EDT

8:05–8:55pm SST

1. **Interference** Two plane waves of wavelength λ are propagating on the xz–plane such that their electric fields at $(x = 0, z = 0)$ reach simultaneously their maximum positive values at $t = 0$. The first plane wave's angle of propagation is $\pi/6$ radians. The second plane wave's angle of propagation is $-\pi/3$ radians, and its amplitude equals $1/2$ of the first plane wave's amplitude. We observe the interference pattern between the two plane waves on a screen parallel to the x axis and located at $z = 0$.

   a) **(10%)** What is the period of the interference pattern? (Express it as fraction of the wavelength λ.)

   b) **(10%)** What is the value of the intensity at $x = 0$? (Normalize such that the first plane wave, if propagating by itself, would produce intensity equal to 1.)

   c) **(10%)** What is the contrast of the interference pattern?

   d) **(10%)** If the first plane wave is phase–shifted by $\pi/2$ radians, what is the new value of the intensity at $x = 0$?

PLEASE TURN OVER
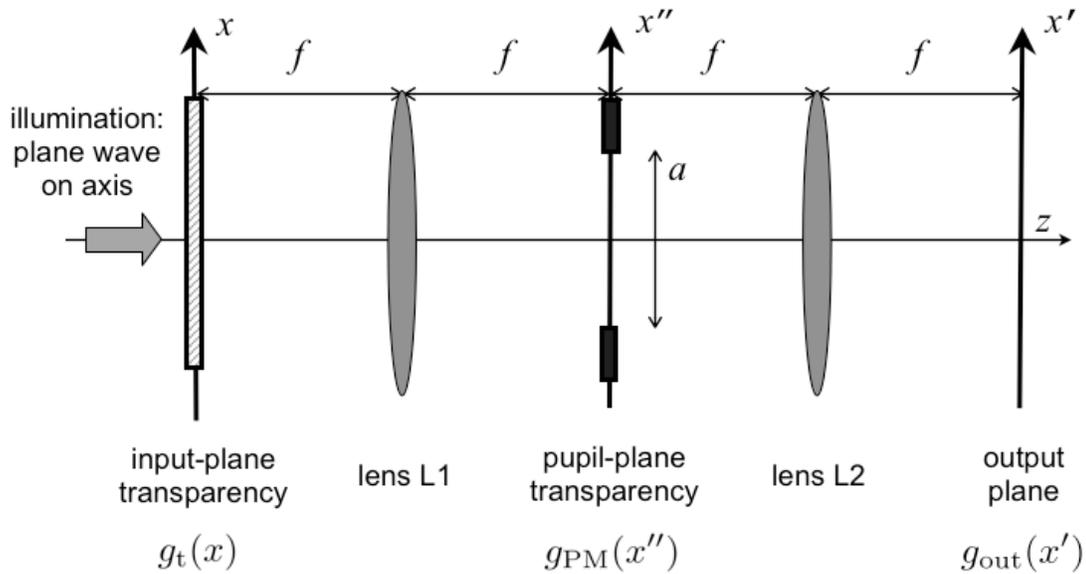
Figure 2.A

2. **Spatial filtering** Figure 2.A above shows a 4F imaging system with two identical lenses L1, L2 of focal length $f = 5$cm. The illumination wavelength is $\lambda = 1\mu$m. The pupil mask is symmetrically placed with respect to the optical axis, it is perfectly transmitting inside the clear aperture a and perfectly opaque outside.

The input transparency is a sinusoidal amplitude grating of period $\Lambda = 10\mu$m and perfect contrast, expressed as

$$g_t(x) = \frac{1}{2}\left[1 + \cos\left(2\pi\frac{x}{\Lambda}\right)\right].$$

a) **(20%)** Express analytically and sketch, with as much detail as possible, the optical field immediately to the left of the pupil plane of the 4F system.

b) **(10%)** What is the minimum size a of the pupil–plane aperture such that the sinusoidal modulation of the input grating be preserved intact at the output?

c) **(15%)** Would your answer change if the illuminating plane wave were to rotate by angle θ with respect to the optical axis? Give an example.

PLEASE TURN OVER
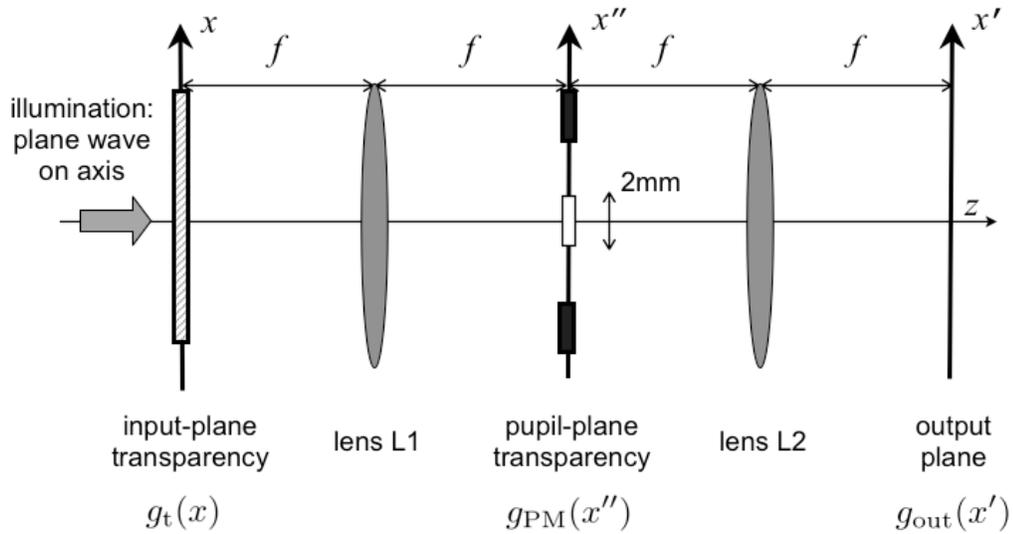
Figure 2.B

d) (15%) Assuming that the lateral size a of the pupil mask is sufficiently large to meet the requirement of question (b), we modify the pupil mask by inserting a small piece of glass symmetrically with respect to the optical axis, as shown in Figure 2.B above. The thickness of the glass is such that the optical field propagating inside the glass suffers a phase delay of π rad compared to the optical field propagating in the surrounding air. Derive an analytical expression and sketch, with as much detail as possible, the intensity $|g_{\text{out}}(x')|^2$ at the output plane of the 4F system.

GOOD LUCK!

2.71 / 2.710 Optics
Spring 2009