2.710

Quiz 2

50 min

8:05–8:55am EDT

8:05–8:55pm SST

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

2.710 Optics **Spring '09**
QUIZ 2 Monday, April 27$^{\text{th}}$, 2009

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

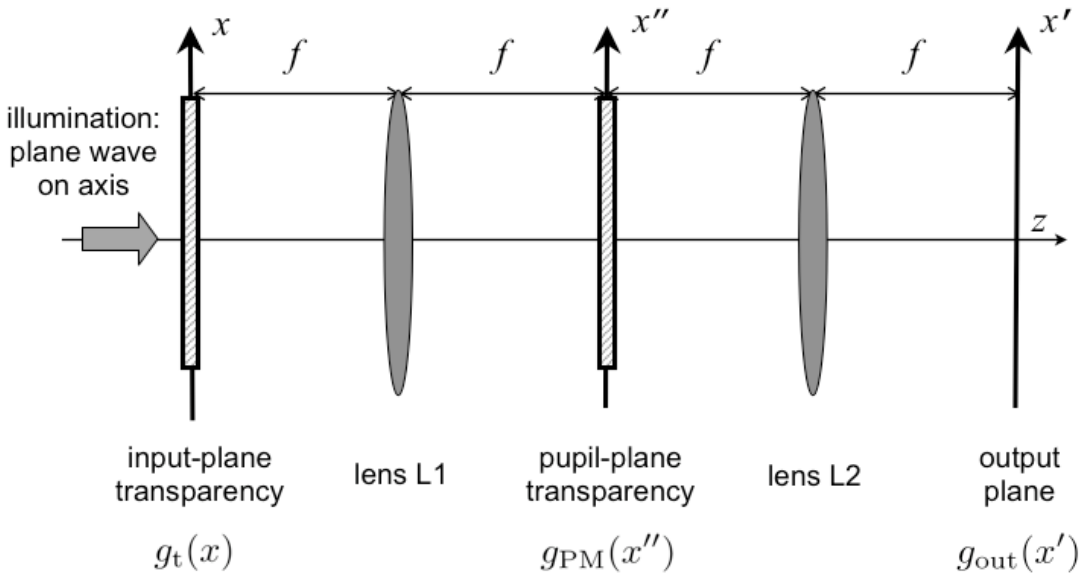

Figure 2.A

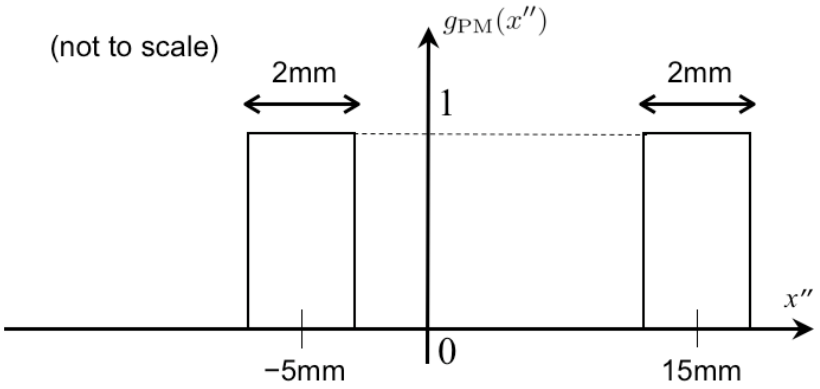

Figure 2.B

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 transmissivity of the pupil mask is shown in Figure 2.B.

The input transparency is a binary amplitude grating of period $\Lambda = 10\mu$m, contrast 100%, and duty cycle 50%. This binary amplitude grating is expressed in a Fourier series as

$$g_{\rm t}(x) = \frac{1}{2}\sum_{q=-\infty}^{+\infty} \text{sinc}\left(\frac{q}{2}\right) \exp\left\{i2\pi q \frac{x}{\Lambda}\right\}, \quad \text{where}$$

$$\text{sinc}\left(\xi\right) \equiv \frac{\sin\left(\pi\xi\right)}{\left(\pi\xi\right)}.$$

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) **(20%)** Express analytically the optical field $g_{\text{out}}(x')$ at the output plane of the 4F system.

c) **(10%)** Evaluate the contrast at the output plane.

d) **(10%)** Your calculations should indicate that a local *minimum* value of the intensity in this imaging system occurs on–axis (*i.e.*, at $x' = 0$). Devise a modification to the *phase transmissivity* of the pupil mask that would result in a local *maximum* value of intensity to occur at $x' = 0$.

GOOD LUCK!

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