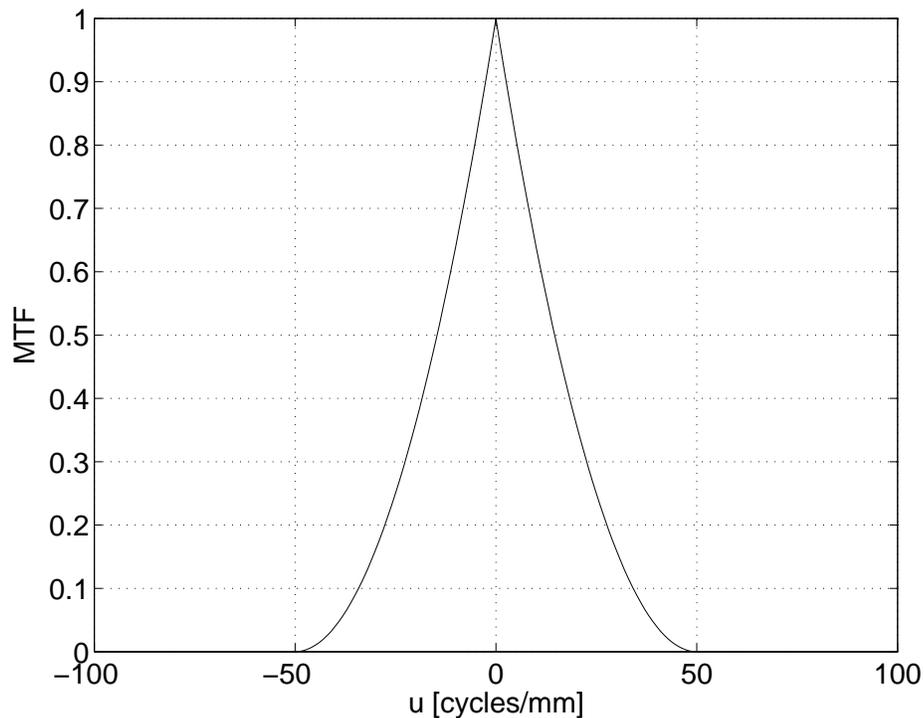


1. In a diffraction-limited imaging system, the contrast is measured at spatial frequency  $25\text{mm}^{-1}$  and it is found to be 68.75%.
  - 1.a) What is the contrast at spatial frequency  $50\text{mm}^{-1}$ ?
  - 1.b) Is the spatial frequency  $50\text{mm}^{-1}$  “visible” through this imaging system under spatially coherent illumination consisting of a plane wave on-axis?
  - 1.c) Does the answer to the previous question change if the on-axis constraint is relaxed, *i.e.* if we allow off-axis plane wave illumination?
  
2. The modulation transfer function (MTF) of an optical system is given in the figure below. The system is illuminated with quasi-monochromatic, spatially incoherent light. The intensity pattern at the input plane of the system is given by

$$I(x) = \frac{1}{2} \left[ 1 + \frac{1}{2} \cos \left( 2\pi \frac{x}{40\mu\text{m}} \right) + \frac{1}{2} \cos \left( 2\pi \frac{3x}{40\mu\text{m}} \right) \right]$$



- 2.a) What is the contrast of the intensity pattern at the input plane?
  - 2.b) Plot the intensity pattern formed at the output plane, and calculate the image contrast.
  - 2.c) Can you guess the coherent transfer function and cut-off spatial frequency for this imaging system?
3. The *coherent* PSF of a 1-D imaging system is given by

$$h(x) = \text{sinc}^2\left(\frac{x}{b}\right),$$

where  $b$  is a fixed distance.

- 3.a) What is the *incoherent* PSF?
- 3.b) What is the MTF?

Hint: make heavy use of the Fourier transform properties.

4. Consider again the optical system shown in page Lecture 22, p. 21 of the Notes, but this time replace the binary amplitude grating with a sinusoidal amplitude grating of perfect contrast

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

All other parameters remain the same, and the illumination incident on the input transparency is still quasi-monochromatic spatially incoherent with uniform intensity.

- 4.a) Derive and sketch the intensity at the output plane.
- 4.b) Compute the contrast.
- 4.c) Compare with the spatially coherent case.

Hint: Don't forget to square the input transparency when you compute the input intensity, *i.e.*  $I_{\text{in}}(x) = |g_t(x)|^2$ .

5. Consider again the optical system shown in page Lecture 19, p. 23 of the Notes, with binary amplitude grating as input transparency, but this time with incident illumination that is quasi-monochromatic spatially incoherent of uniform intensity.
- 5.a) Derive and sketch the intensity at the output plane.
  - 5.b) Compute the contrast.
  - 5.c) Compare with the spatially coherent case.

6. Consider again the optical system with phase pupil mask shown in page Lecture 19, p. 26 of the Notes, where the pupil mask amplitude transmission is as shown in page Lecture 19, p. 27. The illumination incident on the input transparency is quasi-monochromatic spatially incoherent with uniform intensity.
  - 6.a) Derive and sketch the intensity at the output plane.
  - 6.b) Compute the contrast.
  - 6.c) Compare with the spatially coherent case.
7. Consider the lens implementation of the Fourier transform, as described in the Supplement to Lecture 18. Show that the intensity at the Fourier plane is proportional to the autocorrelation of the input field. The input field is defined, as usual, as the product of the illumination field times the complex transmission of the input transparency:  $g_{\text{in}}(x) = g_{\text{illum}}(x) \times g_{\text{t}}(x)$ .

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