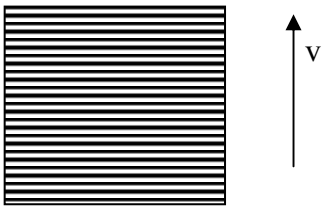
OPTICS, 114210 - Homework Exercises

F2. Diffraction gratings

1. A reflection diffraction grating with spacing d=1.0 μm is blazed for λ=1.0 μm for normal incidence to the grating plane.
(a) Calculate the angle α of the facets.
(b) For what wavelength is the grating blazed in the second order?
(c) What is the diffraction efficiency at λ=0.9 μm?
(d) Draw a schematic diagram showing the angles of the diffraction orders for non-normal incidence
(e) If light is incident at angle α to the grating normal, i.e. normal to the facets, for what wavelength is the grating blazed in the first order?

2. A plane wave of wavelength λ_0 is incident normally on a diffraction grating with spacing d. The grating moves at velocity v in its plane, in a direction normal to the slits. What are the wavelengths of the diffracted beams?



3. An ideal diffraction grating is used to investigate the spectrum of a doublet with wavelengths 589.0nm and 589.6nm. What is the minimum length of a diffraction grating (in the direction perpendicular to the rulings) which could resolve this doublet? If the grating has 800 ruling per mm, how long must it be?

4. Two diffraction gratings, with very narrow slits with spacings d_1 and d_2 (~100λ) are placed one on top of the other with an angle α between the slits. The transmission function is then the *product* of those of the two gratings. What are the diffraction patterns observed when
(a) α=90º
(b) α=60º
(c) α=0 and d_1 and d_2 are approximately (but not exactly) equal.

5. A random two-dimensional grating consists of 1000 holes, each 0.1mm square, situated randomly within a 10mm square opaque frame.
(a) What is its diffraction pattern, as seen on the screen?
(b) What is the size of the central bright spot?
(c) If the holes are arranged so as not to overlap, what difference does this make to the answers to (a) and (b) above?

6. A MEMS video projector device (Texas Instruments: see http://www.prodsys.com/Discovery1100/download/DMD_0.7_XGA_DDR_Product_Preview.pdf) consists of a square array of small mirrors, each of side 13.7 μm, on a

square lattice with period 14.0 μm. The mirrors can be tilted individually about an axis along the *diagonal* of each mirror. Two tilt angles are possible: ±12º, which correspond to "off" and "on". The array has 1024x1024 elements.
(a) How is this device used as a video projector, in which each mirror corresponds to one pixel?
(b) The device is illuminated normally with a coherent plane wave, wavelength 0.5μm. Find the Fraunhofer diffraction pattern of the reflected light, when all the pixels are "on".
(c) Now alternate rows are switched "on" and "off". What is the Fraunhofer diffraction pattern?
(d) A group of four elements, 2x2, is switched "on", all others being "off". What is the diffraction pattern?