

## OPTICS, 114210 - Homework Exercises

### F. Fraunhofer Diffraction

#### 1. Masks.

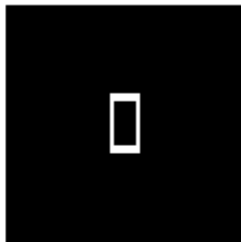
Assume for numerical problems that  $\lambda=0.5\mu\text{m}$  and that diffraction patterns are formed in the focal plane of a lens with focal length 100mm.

1. A mask has two circular holes of diameter 1mm separated by 10mm.
  - (a) Calculate the diffraction pattern observed in the focal plane?
  - (b) One hole is covered by a thin glass plate of thickness 0.1mm and refractive index 1.5. Calculate the diffraction pattern.
  - (c) If the plate is rotated about an axis lying in its own plane, to what angle must it be rotated so that the diffraction pattern is identical to that in (a)?
2. A mask has four square holes with edge 1mm spaced equally in a straight line, with period 8mm. Calculate the diffraction pattern.
3. Find the Fraunhofer diffraction pattern intensities of masks with 5 and 6 pinholes spaced uniformly around a circle. What are the symmetries of these patterns? If you then add a further pinhole at the centre to each one, and compare the patterns with the originals, what does the comparison tell you about the phases? (n.b. you might prefer to do this problem numerically by computer).
4. Find the Fraunhofer diffraction pattern of mask in the form of a chess-board with opaque and transparent squares?
5. Below are five masks, 1-5. On the next page are six Fraunhofer diffraction patterns. A-F. Match one mask to each diffraction pattern. Describe a mask (6) which would give the sixth diffraction pattern (there may be several answers).

1



2



3



4

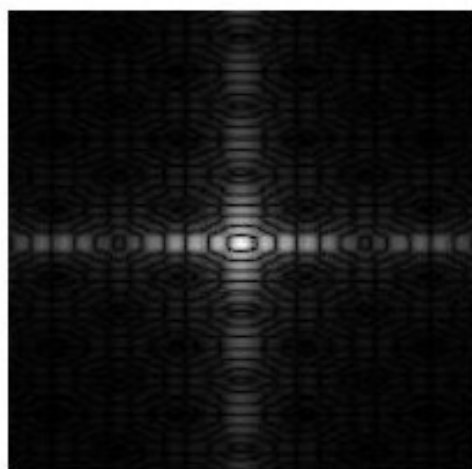


5

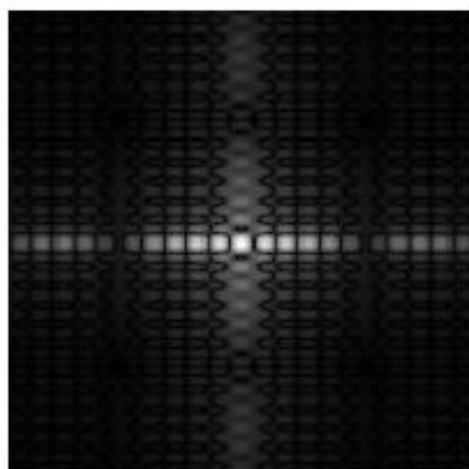


6

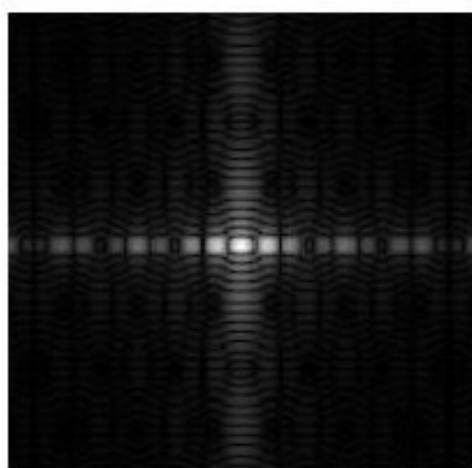
A



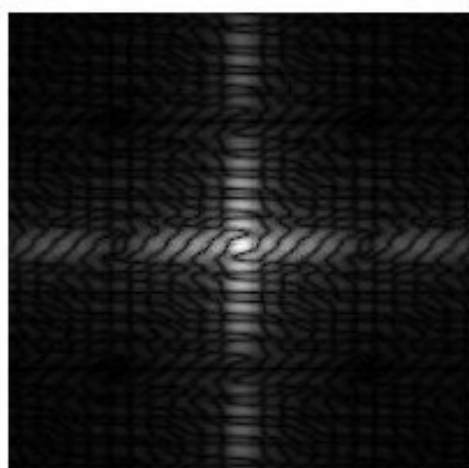
B



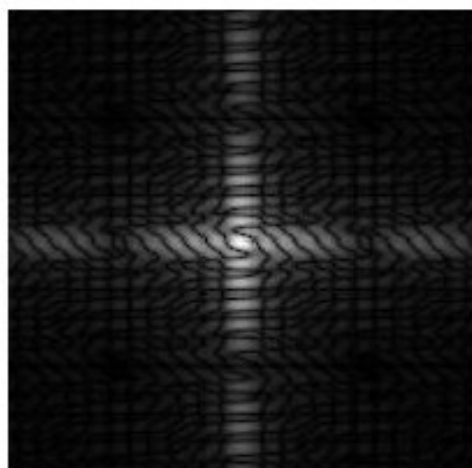
C



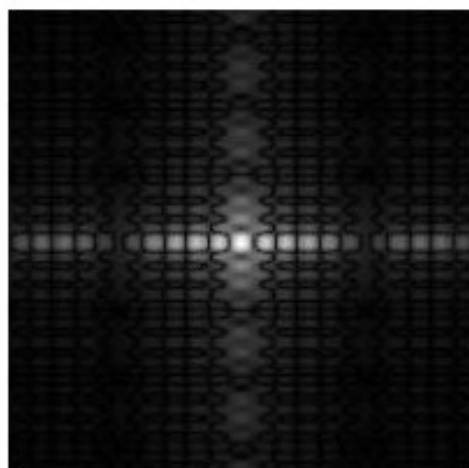
D



E



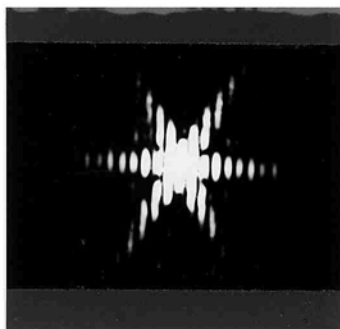
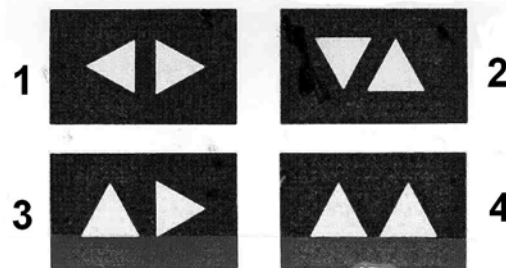
F



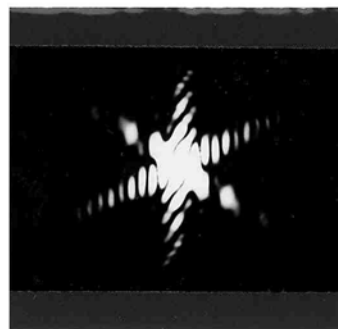
6. Find the Fraunhofer diffraction pattern of six slits forming a  $\text{מגן דוד}$  as a diffraction mask.

7. Two slits of width  $b$  are separated by distance  $a$ . Show that the number of fringes in the central maximum of the diffraction pattern is equal to  $2a/b$ .

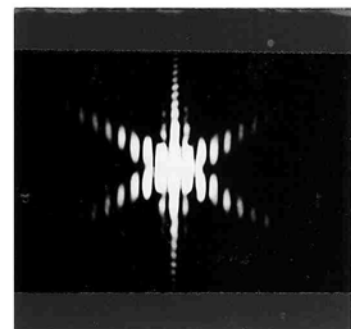
8. Below are four masks, 1-4. and five Fraunhofer diffraction patterns. (a)-(e). Match one mask to each diffraction pattern. Describe a mask of the same family as 1-4 which would give the fifth diffraction pattern (there may be several answers).



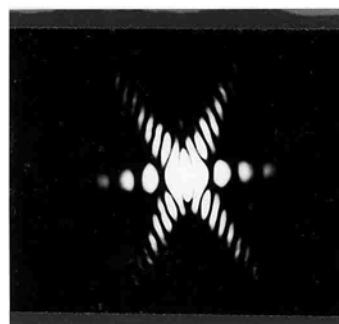
(a)



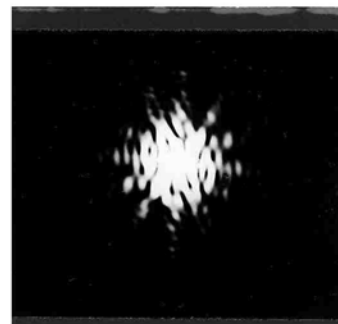
(b)



(c)



(d)



(e)

9. In the first figure below we show 20 geometrical apertures of different types, and in the following figure there are 20 diffraction patterns. You have to match the apertures to their diffraction patterns, and determine the relative orientation of each pair (the patterns may be rotated). All the masks, and all the diffraction patterns, are drawn to the same scale. You will find it convenient to group the masks into different types before starting the matching.

