1. Five slits are illuminated by parallel in-phase light of wavelength λ = 550 nm. The centre-to-centre separation of neighbouring slits is d = 0.025 mm. The light impinges on a distant screen and bright and dark lines are seen at different angles θ to the central (straight-through) light.

(a) What is the angle θ at which the second principal maximum is seen?

(b) What is the angle (φ) at which the very first interference minimum is seen?

For convenience, as all the relevant angles are small, you may approximate $\sin\theta$ by θ.

a/ $2\lambda = d \sin\theta$

$\uparrow_n$

$$\sin\theta = \frac{2\lambda}{d} = \frac{2 \cdot 550 \cdot 10^{-9}}{0.025 \cdot 10^{-3}} = 0.044$$

b) $$\sin\phi = \frac{\lambda}{Nd} =$$

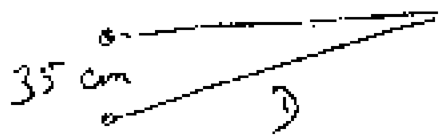
$= 0.0044$

2. In daylight, the pupil of an eye has a diameter of 3.1 mm.

(a) At what distance would two small coloured objects (λ = 600 nm) 35 cm apart by barely resolved by the naked eye, assuming that the spatial resolution is limited only by diffraction?

(b) If cells on the retina are separated by x cm, what is the minimum value of x such that overall resolution is not limited by this cell-to-cell distance, assuming the pupil – retina distance is 2.3 cm.

a/



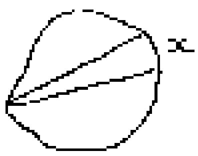
For resolution

$$\frac{35}{D} = 1.22 \frac{\lambda}{w}$$

$$= 1.22 \frac{600\ 10^{-9}}{3.1\ 10^{-3}}$$

$$\underline{D = 1480\ m}$$

b)



$$\frac{35 \times 10^{-2}\ m}{1480} = \frac{x}{2.3\ 10^{-2}}$$

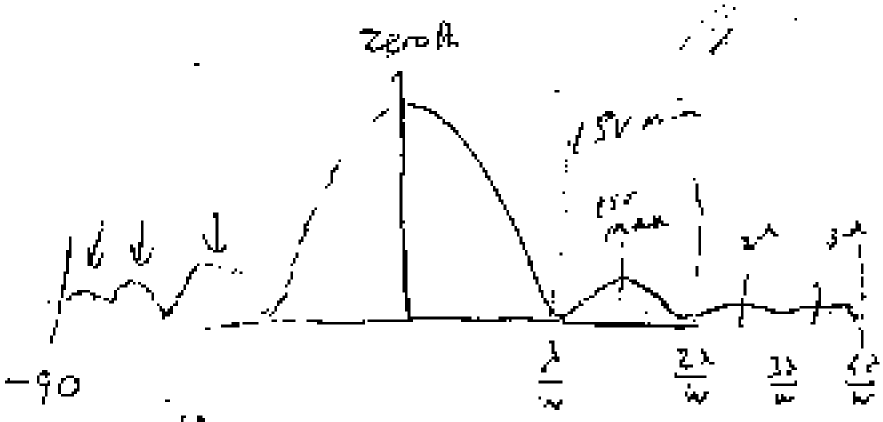
$x =$

$= \underline{5.4\ \mu m}$

3. A single slit has width 4λ. A diffraction pattern is produced on a distant screen. Within the physical constraints of between $\theta = 90°$ and $\theta = -90°$ given by the screen, where θ is the angle between a diffracted ray of interest and the undeviated ray (at $\theta_o = 0$).

(a) How many diffraction maxima are seen?

(b) What are the angles at which the diffraction minima appear?



b) Diff minima $\sin\theta = \frac{\lambda}{w}, \frac{2\lambda}{w}, \frac{3\lambda}{w}, \frac{4\lambda}{w}$

Only this many as $\sin\theta$ cannot exceed 1

a) If 4 minima on each side, total of 7 maxima

(Note that here θ is not small, so $\sin\theta \neq \theta$)

(a)

4. Light beams from two sources, one of which is of wavelength 553.7472 nm and the other of slightly greater than this, pass through a "diffraction grating" with 7706 slits. The two wavelengths are separable (resolvable) in the 4th order.

(a) What is the minimum possible wavelength for the other beam?

(b) If half the slits were blacked-out (let us say slits 1 to 3853), in what order would the beams now be resolvable?

(c) If alternate slits were blacked-out (that is, #2, #4, #6 etc.) in what order would the beams now be resolvable.

a) $\frac{\Delta\lambda}{\lambda} = \frac{1}{Nn}$ $\Delta\lambda = \frac{\lambda}{Nn} = \frac{553.7472 \text{ nm}}{7706 \quad 4}$

$= 0.0179648$ nm

Note the "other" wavelength is 'slightly greater' than 553.7472

So it is 553.7651 nm (or greater)

b) + c) $\frac{\Delta\lambda}{\lambda}$ is the same in a), b), c)

So then is $\frac{1}{Nn}$

If N is halved, n must be doubled, ie 8th order in b) and c)

(a)