The diffraction grating

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Reading of notes / reading memos

Diffraction

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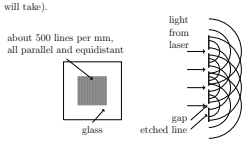
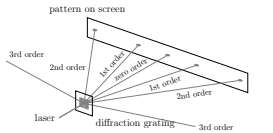
The diffraction grating

A diffraction grating is a sheet of glass, usually about 4 cm square, with many thousands of very narrow parallel lines etched onto one side. These lines make slits with a width of typically have two or three times the wavelength of visible light (meaning that light passing through each individual slit is akin to sound passing through a doorway). The diffraction from the grating's slits is extreme—each one is effectively a source of circular waves as shown below—and the principle of superposition is needed to decide which directions the light will take).



Note that usually lines on a diffraction grating cannot be seen.

When a parallel beam of monochromatic light encounters a diffraction grating at normal incidence, the light beam is split up beyond the grating into a number of transmitted beams. This is due to the superposition of the diffracted light wave patterns from each of the slits in the grating, which leads to their interfering destructvely everywhere beyond the grating except in certain specific directions; in only these directions do they reinforce each other to give a light beam. One of the directions in which light is transmitted is the normal direction (i.e. the same direction as the incident beam), because here the path differences for pairs of slits at equal distance from the centre of the beam are zero, and so these will constructively interfere.



The transmitted beams are conventionally given an order number n outwards from the central 'zero order' beam, and the angle of diffraction θ_n is also measured round from the zero order beam to each transmitted beam. This angle increases (i.e. the beam spots are more spaced out on the screen) as the line spacing of the diffraction grating is decreased, or equivalently as the wavelength of the light is increased.

Lesson Objectives

1. To check our understanding of diffraction.
2. To know how to derive the diffraction grating equation.
3. To be able to answer a simple question on diffraction gratings.

Textbook pp. 205–207

REMINDER: Office hours are week 2 Tuesdays 3.45–5.0 p.m. in room 19.
Next office hours: Tuesday 1 May 2012

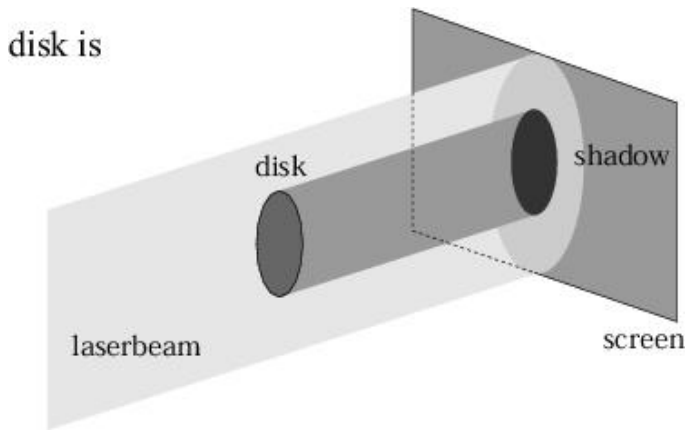
Specification Requirement

Diffraction
The plane diffraction grating at normal incidence; optical details of the spectrometer will not be required.
Derivation of $d \sin\theta = n\lambda$,
where n is the order number.
Applications; e.g. to spectral analysis of light from stars.

[AQA GCE AS and A Level Specification Physics A, 2009/10 onwards]

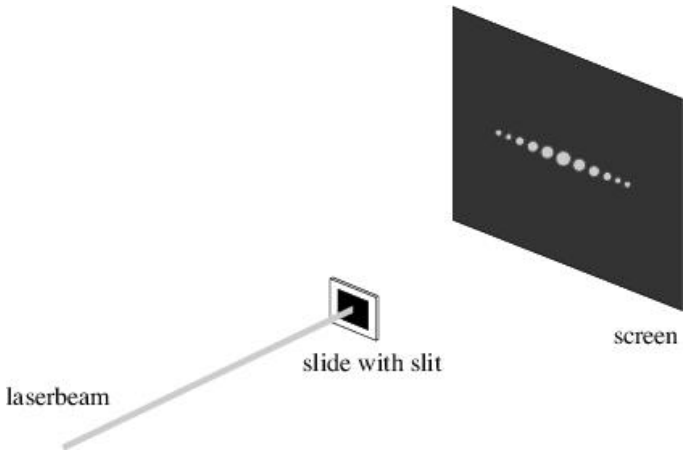
1 Diffraction occurs when light passes a:

(a) pinhole
(b) narrow slit
(c) wide slit
(d) sharp edge
(e) all of the above



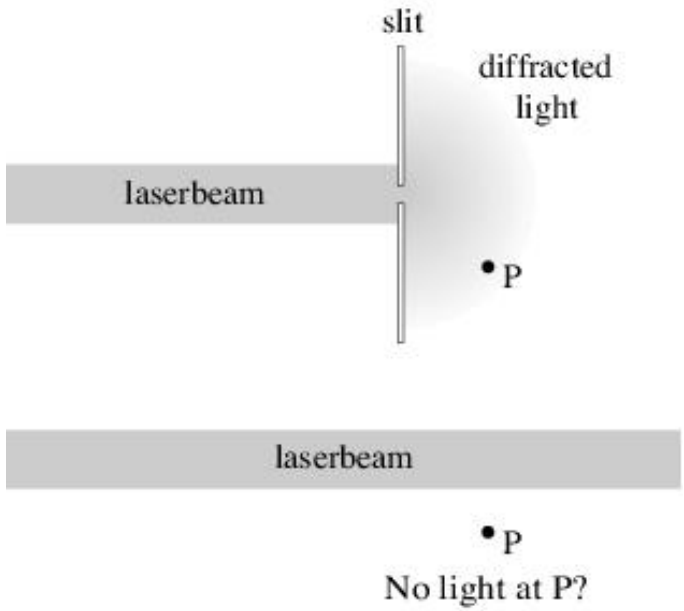
2 Imagine holding a circular disk in a beam of monochromatic light. If diffraction occurs at the edge of the disk, the centre of the shadow of the disk is:

(a) a bright spot
(b) darker than the rest of the shadow
(c) alternately bright and dark, as the distance between the disk and the screen increases
(d) as dark as the rest of the shadow, but less dark than if there is no diffraction



3 The pattern on the screen is due to a narrow slit which is:

(a) horizontal
(b) vertical



3 If light waves can spread out in any direction from the centre of a slit, why doesn't a laser beam without any slit spread out in all directions?

(a) Because all waves that spread interfere destructively
(b) It does spread, but the spread is so small we don't normally notice it
(c) Diffraction doesn't happen anywhere but in slits and apertures

Reading memos

Diffraction grating