State Examination Commission – Physics Higher Level, 2011

Question 3

In an experiment to measure the wavelength of a monochromatic light source, a narrow beam of light was incident normally on a diffraction grating having 400 lines per mm. A number of bright images were observed. The angle θ between the central bright image and the first two images to the left and right of it were measured and recorded in a table, as shown.

	2nd image to left of central image	1st image to left of central image	1st image to right of central image	2nd image to right of central image
θ / °	30.98	14.90	14.81	31.01

Name a source of monochromatic light.
Describe, with the aid of a diagram, how the data was obtained.
Using the data, calculate the wavelength of the monochromatic light. (24)

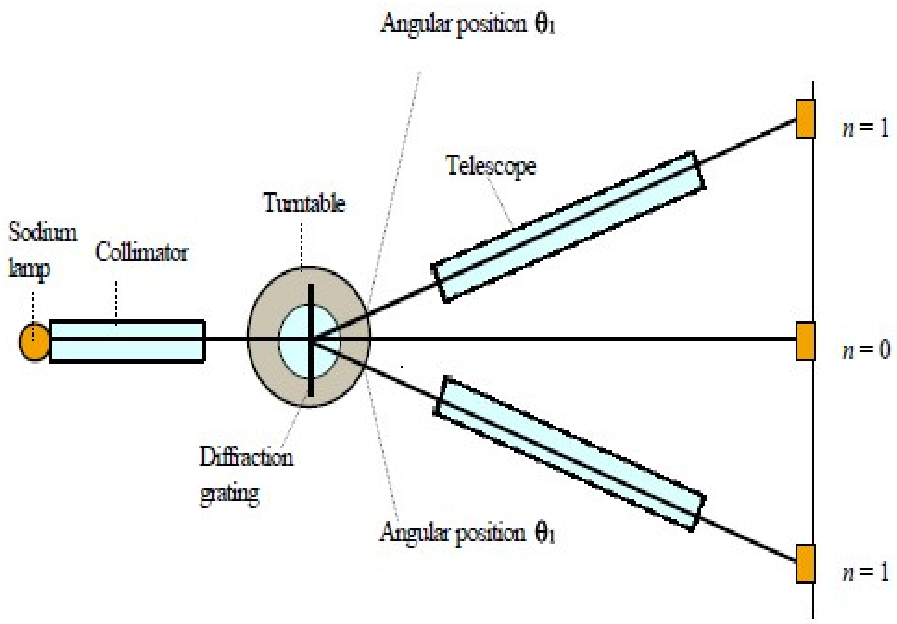
What effect would each of the following changes have on the bright images formed:

i. using a monochromatic light source of longer wavelength
ii. using a diffraction grating having 200 lines per mm.
iii. using a source of white light instead of monochromatic light. (16)

Name a source of monochromatic light.

Sodium vapour lamp

Describe, with the aid of a diagram, how the data was obtained.



Using a correctly set up spectrometer (telescope set up to receive a parallel beam of light with image formd on cross-hairs, and collimator adjusted to produce a sharp image of its illuminated slit) the student aligned the telescope with the straight through (n = 0) position and noted the reading on the angular vernier scale. The student then swiveled the telescope to the left until the first coloured line was visible, and in line with the vertical crosshair, and noted the reading again. By determining the difference between these two readings the value of θ for 1st image to left of central image was obtained. This was repeated for the other three readings.

Using the data, calculate the wavelength of the monochromatic light.

$$Using\ the\ formula\ \lambda_n = \frac{(d \sin\theta_n)}{n}$$

$$\theta_1 = \frac{(14.90^0 + 14.81^0)}{2} = 14.86^0 \Rightarrow \lambda = \frac{(2.5\,x\,10^{-6}\,x \sin 14.86^0)}{1} = 6.41\,x\,10^{-7}\,m$$

$$\theta_2 = \frac{(30.98^0 + 31.01^0)}{2} = 31.00^0 \Rightarrow \lambda = \frac{(2.5\,x\,10^{-6}\,x \sin 31.00^0)}{2} = 6.44\,x\,10^{-7}\,m$$

$$\Rightarrow \lambda = \frac{(6.44\,x\,10^{-7} + 6.41\,x\,10^{-7})}{2} = 6.43\,x\,10^{-7}\,m$$

What effect would each of the following changes have on the bright images formed:

Since Sin θ = nλ/d

i. using a monochromatic light source of longer wavelength,

increases the value of sin θ , and hence the value of θ. The images will have a greater angular separation.

ii. using a diffraction grating having 200 lines per mm,

means that d is greater, so sin θ , and hence θ, will be smaller. The images will have a smaller angular separation.

iii. using a source of white light instead of monochromatic light. (16)

Apart from the zero'th order (straight through position where white light is observed), continuous spectra of light appear on both sides of the slit where before there were just single lines.