7 **(a)** A plane wave passes through an aperture.

State and explain the effect of the width of aperture on the diffraction of the wave.

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…………………………………………………………………………………………… [2]

(b) A diffraction grating is illuminated normally by a monochromatic light source of wavelength λ as shown in Fig. 7.1. Light rays from each slit travel a different distance before arriving at a particular point on a screen distance D away. θ is the angle between the diffracted ray and the normal.

In order to derive an expression for the path difference x, the light rays that meet at the same point on the screen can be **approximated** as parallel rays.

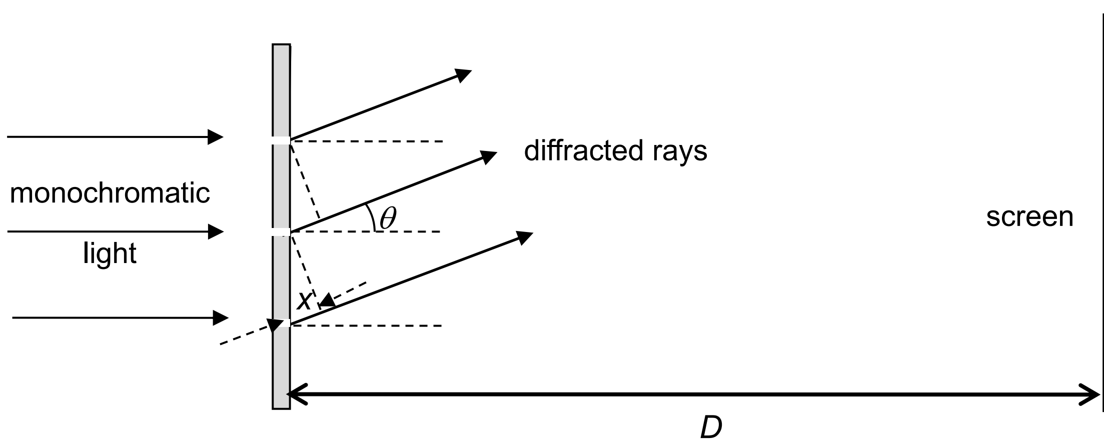

Fig. 7.1

(i) State the condition where the rays can be assumed to be parallel.

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……..……………………………………………………………………………………….. [1]

(ii) Derive an expression for the path difference x between adjacent rays in terms of p and θ, where p is the number of lines per unit length of the grating. [2]

(iii) Hence, derive an expression relating p and θ for the constructive interference of the rays.

Define any additional symbol(s) you use. [2]

(c) A diffraction grating is set up at the centre of a rotating table which completes a revolution every 3.0 s. The grating is illuminated normally by monochromatic light of wavelength λ from a source which is also mounted on the table as shown in Fig. 7.2.

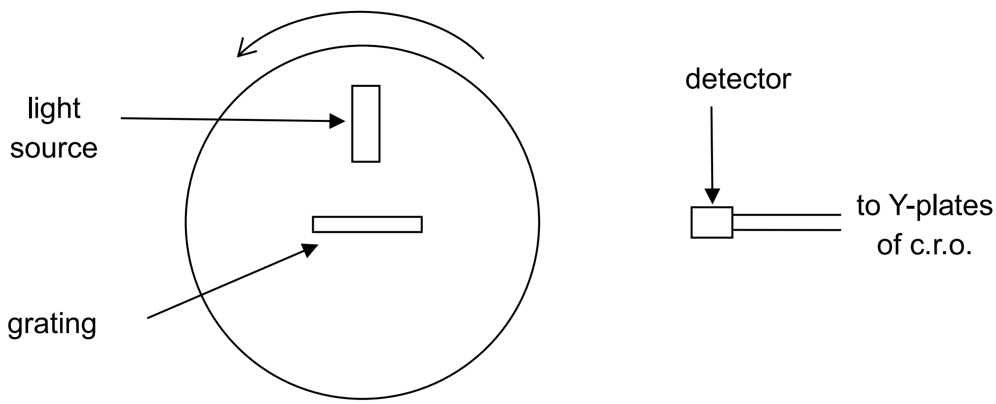

Fig. 7.2

The emergent beams of light from the grating are monitored by means of a stationary opto-electrical detector. The output from the detector is displayed on a cathode ray oscilloscope (c.r.o.). With the time-base set at 0.10 s cm^{-1}, the trace obtained is shown in Fig. 7.3. The relative positions of the peaks are as indicated.

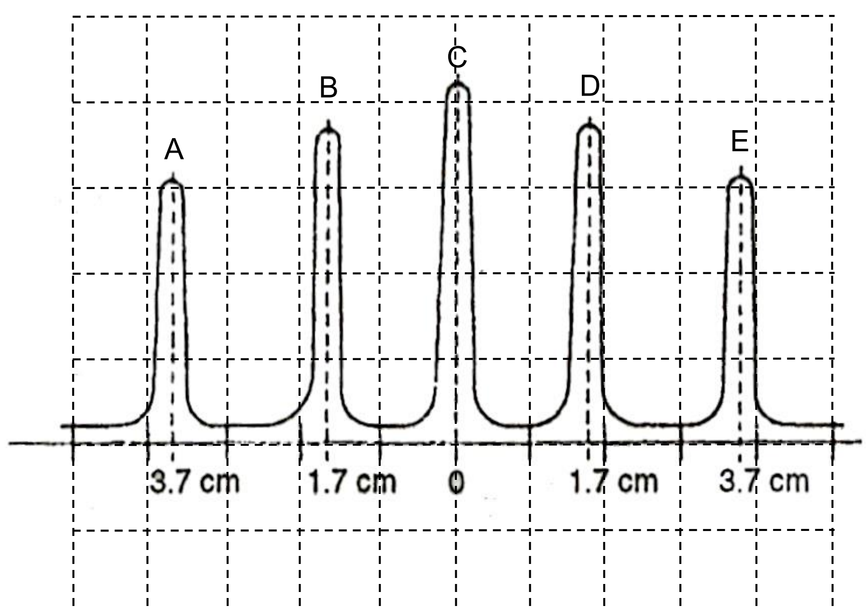

Fig. 7.3

(c) **(i)** Calculate the angular speed of rotation of the grating.

angular speed = …………………….rad s^{-1} [1]

(ii) Explain the appearance of the trace in Fig. 7.3 by stating the order of diffraction of the peaks and the variation in heights.

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……..……………………………………………………………………………….. [2]

(iii) Show that the angle θ in radians, for peak D is 0.36 rad and hence find the angle for peak E.

θ for E = …………… radians [3]

(iv) Using peak E, calculate the wavelength of the light if the grating has 550 lines per mm.

wavelength = ……………………. nm [2]

(v) Explain why it is preferable to calculate the wavelength using peak E rather than peak D.

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……..………………………………………………………………………………….. [1]

(vi) Sketch in Fig. 7.4, what will be observed on the c.r.o. display, if the diffraction grating is replaced by a double slit of the same slit separation as the diffraction grating. [2]

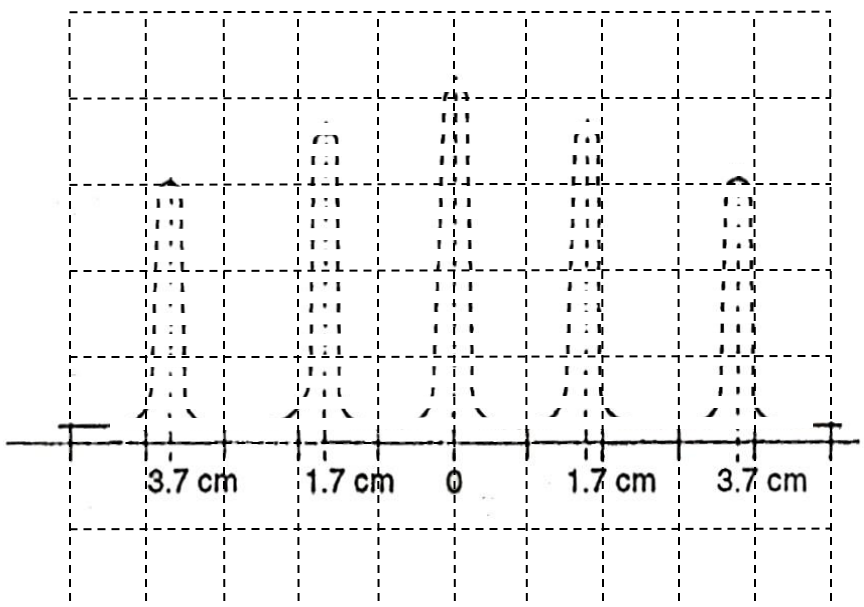

Fig. 7.4

(The original display from the grating is shown in dotted lines.)

(vii) Explain the appearance and the changes (if any) of the trace in Fig. 7.4.

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