Experimental Question 2

Diffraction and Scattering of Laser Light

The aim of this experiment is to demonstrate and quantify to some extent the reflection, diffraction, and scattering of light, using visible radiation from a Laser Diode source. A metal ruler is employed as a diffraction grating, and a perspex tank, containing water and diluted milk, is used to determine reflection and scattering phenomena.

Section 1 (6 marks)

Place the 150 mm length metal ruler provided so that it is nearly normal to the incident laser beam, and so that the laserr beam illuminates several rulings on it. Observe a number of "spots" of light on the white paper screen provided, caused by the phenomenon of diffraction.

Draw the overall geometry you have employed and measure the position and separation of these spots with the screen at a distance of approximately 1.5 metres from the ruler.

Using the relation

$$N\lambda = h \sin\beta$$

where N is the order of diffraction
λ is the radiation wavelength
h is the grating period
β is the angle of diffraction

and the information obtained from your measurements, determine the wavelength of the laser radiation.

Section 2 (4 marks)

Now insert the empty perspex tank provided into the space between the laser and the white paper screen. Set the tank at approximately normal incidence to the laser beam.

(i) Observe a reduction in the emergent beam intensity, and estimate the percentage value of this reduction. Some calibrated transmission discs are provided to assist with this estimation. Remember that the human eye has a logarithmic response.

This intensity reduction is caused primarily by reflection losses at the aid/perspex boundaries, of which there are four in this case. THe reflection coefficient for normal incidence at each boundary, R, which is the ratio of the reflectied to incident intensities, is given by

$$R = \{(n_1 - n_2)/(n_1 + n_2)\}^2$$

where n_1 and n_2 are the refractive indices before and after the boundary. The corresponding transmission coefficient, assuming zero absorption in the perspex, is fiven by

$$T = 1 - R \quad .$$

(ii) Assuming a refractive index of 1.59 for the perspex and neglecting the effect of multiple reflections and cogerence, calculate the intensity transmission coefficient of the empty perspex tank. Compare this result with the estimate you made in Part (i) of this Section.

Section 3 (1 mark)

Without moving the perspex tank, repeat the observations and calculations in Section 2 with the 50 mL of water provided in a beaker now added to the tank. Assume the refractive index of water to be 1.33.

Section 4 (10 marks)

(i) Add 0.5 mL (12 drops) of milk (the scattering material) to the 50 mL of water in the perspex tank, and stir well. Measure as accurately as possible the total angle through which the laser light is scattered, and the diameter of the emerging light patch at the exit face of the tank, noting that these quantities are related. Also estimate the reduction in transmitted intensity, as in earlier sections.

(ii) Add a further 0.5 mL of milk to the tank, and repeat the measurements requested in part (i).

(iii) Repeat the process in part (ii) until very little or no transmitted laser light can be observed.

(iv) Determine the relationship between scattering angle and milk concentration in the tank.

(v) Use your results, and the relationship

$$I = I_0 e^{-\mu z} = T_{milk} \times I_0$$

where	I_0	is the input intensity
	I	is the emerging intensity
	z	is the distance in the tank
	μ	is the attenuation coefficient and equals a constant times the concentration of the scatterer
	T_{milk}	is the transmission coefficient for the milk

to obtain an estimate for the value of μ for a scatterer concentration of 10%.