5. Candy wrapper

The setup is as follows. First the candy wrapper is cut in half and then wound around the hexagonal pencil on both ends A times and fixed tightly against the other pencil using the rubber bands. That way there is a gap of width Ad between the two pencils. The laser light is directed through the gap between the two pencils and the resulting diffraction pattern is displayed on the screen (which is fixed vertically to the stand). We can keep the pencils and laser horizontal using the given clamps and adjust the height of the laser so it passes through the gap by placing sheets of paper below the laser. Because the pencil surface is rough the gap between the pencils varies. In order to diminish this effect we can put more layers of the candy wrapper between the pencils. The resulting experimental values are displayed on the table, where N is the number of local maxima or minima on the screen, a is the distance between the first and last measured maximum or minimum and L is the distance from the screen to the pencils. Note that the central maximum is double-wide and we have to take it into account when counting minima (as it covers one minimum) and take it into account twice when counting maxima.

A	N	$a\,(\mathrm{cm})$	$L\,(\mathrm{cm})$	$d\,(\mu\mathrm{m})$
12	21	2.4	70	20
12	14	1.6	63	29
8	9	1.3	60	23

Let θ be the angle of incidence of the laser light that lands on the screen. Then the difference between the angles for the different maxima or minima can be expressed as $\theta \approx \frac{a}{L}$ using the small angle approximation. The number of maxima or minima can be expressed using $A\theta d = N\lambda$. Then

$$d = \frac{N\lambda}{A\theta} = \frac{N\lambda L}{Aa}$$

Using the data from the table we get $d = 25\,\mu\mathrm{m}$. The main contributing factor for uncertainty comes from the roughness of the pencil which can be estimated using the maximal and minimal values of measured wrapper thickness. Then $\Delta d \approx \frac{d_{\max} - d_{\min}}{2} = 4.5\,\mu\mathrm{m}$.