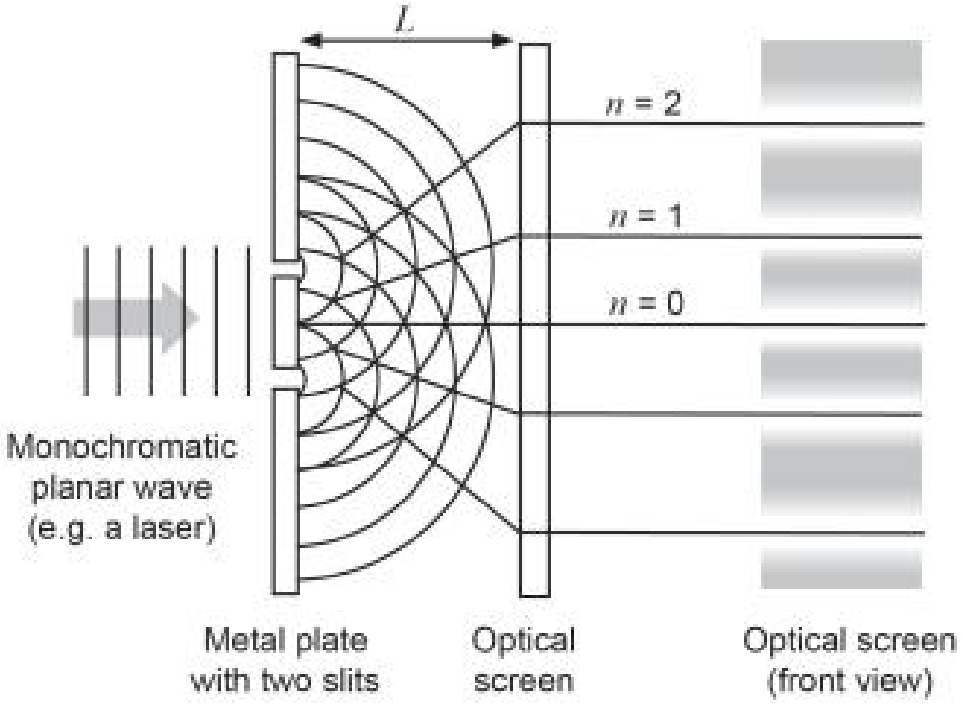
**Question 17** **(17 marks)**

The first serious challenge to the particle theory of light was made by the English scientist Thomas Young in 1803. Young reasoned that if light were actually a wave phenomenon, as he suspected, then a similar interference effect observed with sound waves should occur for light. This line of reasoning led Young to perform an experiment which is nowadays referred to as 'Young's double-slit experiment'.

In Young's double-slit experiment, two very narrow parallel slits, separated by a distance $d$, are cut into a plate made of thin metal. Monochromatic light, from a distant light source, passes through the slits and eventually hits an optical screen a comparatively large distance $L$ from the slits. The experimental setup is shown in the diagram below.




Young observed a series of alternating parallel light and dark bands on the screen, with the central band being bright.

From his research, he established the following relationship between $L$, the distance between the slits and the screen; $d$, the distance between the two slits; $\lambda$, the wavelength of the monochromatic light and $x$, the distance between the centres of adjacent light bands in the interference patterns:

$$\frac{x}{L} = \frac{n\lambda}{d}$$

A group of students set up an experiment to measure the wavelength of light produced by a laser pointer. Using a commercially-produced metal plate where $d = 2.19 \times 10^{-5}$ m, they varied the distance from the slits to the optical screen ($L$) and measured the distance between the centre light band and the one closest to it ($n = 1$). Their results are shown in the table below.

| $L$ (m) ± 0.002 m | 0.400 | 0.800 | 1.200 | 1.300 | 1.400 | 1.500 |
|---|---|---|---|---|---|---|
| $x$ (m × $10^{-2}$) ± 0.002 m | 1.12 | 2.21 | 3.06 | 3.76 | 4.28 | 4.38 |

(a) Graph $x$ vs $L$ on the grid paper provided on page 23. Include the line of best fit. Do **not** include uncertainties. (5 marks)

(b) From your graph, calculate the gradient of the line of best fit. Show construction lines on your graph. Use correct significant figures. (3 marks)

(c) Using the gradient from part (b), calculate the wavelength of the monochromatic light used. Use correct significant figures. (4 marks)

_____ nm

The students were disappointed when they found their answer was 10% different from the wavelength supplied by the manufacturers of the laser pointer. When the teacher helped them use the uncertainties associated with their experiment, they found the manufacture's value fell within the accepted range of uncertainty.

(d) Using the same values as in part (b), recalculate your gradient including uncertainties to show that a 10% difference falls within the accepted range. (5 marks)