ENGINEERING OPTICS
SPECIMEN EXAM PAPER

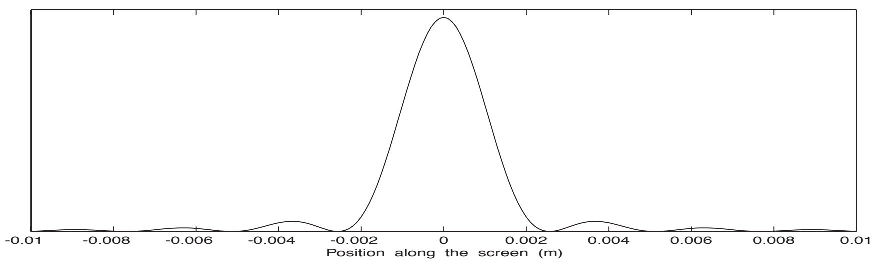
Using the software you have been working with for the last 9 weeks and consulting any written material you like, answer as many of the following questions as you can in 50 MINUTES.

This exam will count for 36 marks out of a total of 50 for the course.

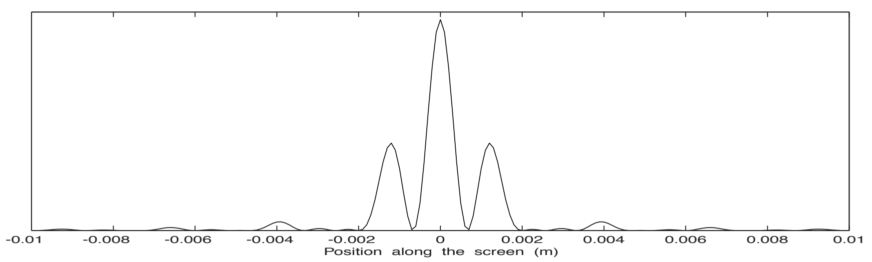
Question 1

When answering the three parts of this question, always indicate the scale on the horizontal (position along the screen) axis. You need not show the scale on the vertical (intensity) axis, which is arbitrary.

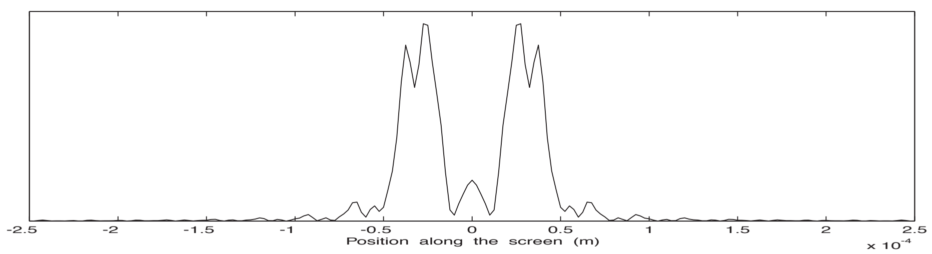
(a) Plane wave light, of wavelength 400 nm, is shone onto a single slit, of width 0.030 mm. The Fraunhofer diffraction pattern is observed on a screen 20 cm from the slit. Draw a diagram to show how the intensity of the pattern changes with distance along the screen. Choose a scale on the horizontal axis which extends between $\pm 1.0 \times 10^{-2}$ m.



(b) A second slit is introduced of the same width, with the centres of the slits separated by 0.060 mm. Draw a similar diagram to show how the intensity of the pattern changes with distance across the screen, still at 20 cm from the slits.



(c) The screen is now brought much closer to the two slits, so that the slit–screen distance is 2.0 mm. Draw now the Fresnel diffraction pattern. Choose a scale on the horizontal axis which extends between $\pm 2.5 \times 10^{-4}$ m.



Question 2

(a) The light from a mercury lamp is being examined with a transmission grating. The green line, whose wavelength is 546 nm, is observed in second order to appear at 18.5°. How many lines per mm, to 3 significant figures, must the grating have?

Number of lines per mm: **291**

(b) A light source emits two narrow spectral lines with wavelengths close to 450 nm. You have a grating of 50 slits, each separated by 0.0020 mm. What is the smallest difference between the wavelengths of the two spectral lines which will allow them to be resolved by this grating, in third order? (Quote your answer to one significant figure only.)

$\Delta\lambda$ *(third order):* **3 nm**

Question 3

You are using an optical fibre Mach-Zehnder interferometer to measure small changes in the refractive index of a sample of an electro-optic material. The refractive index of the fibres themselves is 1.520, and the working wavelength is 1500 nm. The zero-field refractive index of the sample is 2.300, and its length (not dependent on the electric field) is 12.0000 cm.

(a) With these figures, is the output of the interferometer maximum, minimum or somewhere in betweem.

output of the interferometer: **Very close to maximum**

(b) The external voltage is increased slowly from zero, and the output falls to a minimum. By how much does the refractive index change during this process? Quote your answer to one significant figure.

change in n: $\mathbf{6 \times 10^{-6}}$

Question 4

A certain Fibre Bragg grating is 4.0 cm in length. The refractive index of its core fluctuates periodically between the values 1.5500 ± 0.0001; there being 80 000 complete cycles along its length. Assume that the fluctuation in refractive index can be modelled as regular, abrupt changes up and down like a square wave.

(a) What is the Bragg wavelength of this fibre (to three significant figures)?

λ_B: **1550 nm**

(b) Would this grating be considered a weak, medium or strong grating? State which of these three choices is correct and state briefly the reason you believe that choice is correct.

Strong.
A strong grating is one whose "strength", $qL \gg 1$, and
he strength of this grating is 10.3; or
The curve has a flat top to it.