

### Optical Communications project 2022-23

Your group will be given the parameters of a step-index cylindrical fibre ( $n_1, n_2, a$ ) and the wavelength of light that is to be transmitted.

The formulae and methods that you need are given in the lecture notes for lectures 3, 4 and 6.

Using the approximation that  $n_1 \approx n_2$ , you should attempt the following tasks working in your allocated groups. You should each expect to spend about 15 hours on the project.

1. Calculate the V-parameter for the fibre.
2. Decide whether you are going to consider the {TE, TM, EH, HE} or LP modes for all of the subsequent tasks.
3. Identify all the modes that the fibre supports and the propagation constant and effective index for each mode. Summarise the results as a table.
4. Excluding the fundamental mode {HE<sub>11</sub>/LP<sub>01</sub>}, pick one of the modes from your table for the tasks below.
5. Plot maps in the plane perpendicular to the fibre axis of the amplitude of all three E-fields within the fibre. You will need to fix one of the  $A$  or  $B$  parameters, e.g. to unity, and use the relevant equations to calculate the other values. You can choose to do this for either the {radial, tangential,  $z$ } or { $x$ ,  $y$ ,  $z$ } E-field components.
6. Plot the spatial distribution of the total intensity of the mode in the direction perpendicular to the fibre axis, e.g. sum of the square modulus of the field in the {radial, tangential} or { $x$ ,  $y$ } directions.
7. Calculate numerically the waveguide dispersion  $D_w = -\frac{\lambda}{c} \left[ \frac{\partial^2 n_{eff}}{\partial \lambda^2} \right]_w = -\frac{\lambda}{c} \left[ \frac{\partial^2 n_m}{\partial \lambda^2} \right]_w$  for the mode selected, see notes for lecture 6. For example, calculate this from the effective index calculated for three (or more) wavelengths close to the wavelength of light to be transmitted.
8. Using your result to part 6, calculate the fraction of energy in the core and cladding by summing over the relevant regions. Use equation  $n_{eff}^2 \approx n_1^2 \Gamma(V) + n_2^2 (1 - \Gamma(V))$  to calculate an approximate value for the effective index. Compare this value of the effective index to the value you calculated directly and comment on your result.

Do come and ask questions in office hours (Thursdays 1-2pm room 622 Blackett) if you need.

Think about how you can divide the work between the members of your group and agree in advance how you are going to do this.

You can use your choice of programming language to perform the calculations.

You need to submit the following via Turnitin on Blackboard by 5pm on Monday 12<sup>th</sup> December:

- A pdf of an A1 poster displaying a summary of your results.
- The concisely commented code that you used to perform your calculations and generate your plots.
- A max 2-page Methods document that concisely summarises the calculations and methods used in your code.

The posters will be printed and discussed with the groups at the session at 9am on Thursday 15<sup>th</sup> December.

The project will be assessed according to the following equally weighted criteria:

- Use of English, clarity and presentation of poster

A good poster should be as concise as possible and avoid large blocks of text. Try and communicate what you have done as effectively as possible. Figures should be clear and all fonts should be large enough to read easily. (A good guide is that everything on the poster should be able to be read comfortably if it is printed out at size A4.) Figures should be well labelled, and the captions should enable a knowledgeable reader to understand what is shown without referring to the main text. There should be a concise abstract and a concise summary of the key results.

- Quality of results presented in poster

The work should be undertaken at a suitably high level and use appropriate mathematical and computational methods. The result should be described and, where appropriate, interpreted correctly.

- Clarity of commented code and Methods document

The comments in the codes should be concise and explain in plain English (avoiding terms specific to the programming language used) what relevant lines or groups of lines achieve. The Methods document should provide a concise summary of the equations solved and the methods used to solve them. For example, you should briefly introduce the relevant equation, together with defining all symbols, and then state something like 'Numerical solutions to equation X were found using the Python function Y which implements method Z for finding the roots of an equation'. The Methods document only needs to be as long as is required, you do not have to fill 2 pages, the 2 pages is a maximum.