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THE NATIONAL UNIVERSITY OF IRELAND, CORK

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UNIVERSITY COLLEGE, CORK

Sample Paper 2001

B.E. DEGREE (ELECTRICAL AND ELECTRONIC)
HIGHER DIPLOMA IN PHYSICS

OPTICAL ELECTRONICS (EE4007)

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3 HOURS

The use of approved calculators is permitted.

FIVE QUESTIONS TO BE ANSWERED, AT LEAST TWO FROM EACH SECTION.
USE SEPARATE ANSWER BOOKS FOR EACH SECTION

Physical Constants:
Free electron mass, $m_0 = 9 \times 10^{-31}$ kg
Planck's constant, $h = 6.624 \times 10^{-34}$ J s
Electronic charge, $q = 1.6 \times 10^{-19}$ C
Boltzmann's constant, $k_B = 1.38 \times 10^{-23}$ J K^{-1}
Room temperature = 300 K

Questions follow overleaf/…

SECTION B

5. (a) Describe the differences between multimode plastic optical fibre and single-mode silica fibre. Give applications for both.

   (b) Draw a schematic representation of a broadcast network, labeling each major component.

   (c) The laser power coupled into a single-mode glass fibre is 1.5mW at 1.55μm. The fibre attenuation at this wavelength is 0.15dB km^{-1}. Calculate the maximum length the fibre can be (without amplification) to allow the signal to be detected with a receiver having a –35dBm sensitivity if a 5dB link margin is expected. You may assume dispersion and other losses are negligible.

6. (a) Explain what is meant by the following:

   (i) Receiver sensitivity
   (ii) Link margin
   (iii) Brewster angle
   (iv) Critical angle
   (v) attenuation constant
   (vi) material dispersion

   (b) Compare the spectral linewidth of an LED with (a) Fabry-Perot semiconductor laser diode, (b) Nd:YAG laser , (c) HeNe laser

   (c) If the material dispersion in pure silica is 15 ps nm^{-1} km^{-1} at 1.55μm. Calculate the pulse spreading in a 200 km silica fibre for an LED operating at 1.55μm, having a 35 nm spectral width. What length of fibre would be required to have the same amount of pulse spreading if a laser diode operating at the same wavelength had been used? State any assumptions you make.

   (d) What is the net effect of dispersion on a fibre communication link? Give three solutions to minimise dispersive effects.

7. (a) Draw a schematic representation of a symmetric slab waveguide, labeling the main features and describing the refractive index relationships between the different layers.

   (b) Describe with the aid of diagrams why the symmetric slab waveguide is a good approximation for a double heterostructure laser diode.

   (c) Given the TE mode chart, find the propagation angles, effective refractive indices, and the number of TE modes in an AlGaAs symmetric slab waveguide, if the waveguide thickness is 1.64μm and the free-space wavelength is 0.82μm. What thickness must the waveguide be to guarantee single mode operation at this wavelength?

   (d) Give two uses for symmetric slab waveguides.

8. (a) Draw a schematic representation of a Fabry-Perot laser diode. Describe why it is not a suitable source for high-speed optical communications. What modifications can be made to the Fabry-Perot laser to make it suitable for high speed optical communications?

   (b) Describe two techniques for modulating a semiconductor laser source for use in a communication system. Use diagrams to help explain your answer.

   (c) What laser materials are most suited for use in long-haul telecommunication systems? Why?

   (d) Describe with the aid of diagrams a fabrication procedure for making an oxide stripe geometry Fabry-Perot laser diode.