



MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPH 338: OPTICAL FIBRE COMMUNICATION SYSTEMS AND NETWORKS

DATE:

TIME:

INSTRUCTIONS TO CANDIDATES

Answer QUESTION ONE and ANY OTHER TWO questions.

Question 1 carries **30** marks and the others carry **20** marks each.

YOU MAY USE:

You may need to use the following constants:

$c = 2.998 \times 10^8 \text{ m/s}$, Boltzmann's constant, $K = 1.38 \times 10^{-23} \text{ m}^2 \text{ kg s}^{-2} \text{ K}^{-1}$, Plank's constant = $6.63 \times 10^{-34} \text{ m}^2 \text{ kg/s}$

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) Define an endoscope (1 mark)
- b) Identify three advantages of using vertical cavity surface emitting lasers (VCSELs). (3 marks)
- c) Based on geometry, identify the two types of optical waveguides and their respective applications in the field of optics. (4 marks)
- d) A step-index fibre has a numerical aperture of 0.26, a core refractive index of 1.5 and a core diameter of $100 \mu\text{m}$. Calculate the acceptance angle (2 marks)
- e) A photodiode has a capacitance of 6 pF. Calculate the maximum load resistance which allows an 8 MHz post detection bandwidth. (3 marks)

- f) Identify the advantages of using optical fibre transmissions over copper. (3 marks)
- g) Consider a step-index fibre $n_2 = 1.447$, $\Delta n = 0.003$ and $a = 4.2 \mu m$. Calculate;
 - (i) the cut-off wavelength (3 marks)
 - (ii) the V-parameter for this fibre. (2 marks)
- h) List any three digital signal modulation techniques (3 marks)
- i) Identify techniques for reducing bend losses in an optical fibre connection. (3 marks)
- j) Differentiate between active and passive components of an optical fibre network system and give an example of each. (3 marks)

QUESTION TWO (20 MARKS)

- a) Describe the components of a fibre optic cable (6 marks)
- b) A silicon p-i-n photodiode incorporated in an optical receiver has following parameters: Quantum efficiency = 70 %, wavelength = $0.8 \mu m$, dark current = 3 nA, load resistance is $4 k\Omega$, incident optical power = 150 nW and bandwidth = 5 MHz. Calculate the photocurrent in the device. (4 marks)
- c) While diagnosing a lab setup, you realized that your link is experiencing signal power losses due to reflection, and you needed to eliminate this. Identify the different methods/techniques you would use to eliminate the losses (4 marks)
- d) While providing their solutions, identify three mechanisms that degrade the operation and lifetime of optical lasers (6 marks)

QUESTION THREE (20 MARKS)

- a) Consider a G.652 fibre for which $n_2 = 1.444$, $\Delta n = 0.0075$, and $a = 2.3 \mu m$. Calculate;
 - (i) the material (2 marks)
 - (ii) waveguide (2 marks)
 - (iii) total dispersion for this fibre (1 mark)
- b) Describe any two multiplexing techniques (4 marks)
- c) Discuss the operation principle and advantages of an erbium doped fibre amplifier (EDFA). (6 marks)
- d) Describe the structure and the operational principle of an Avalanche photodiode. (5 marks)

QUESTION FOUR (20 MARKS)

- a) Identify the digital characteristics of an eye diagram (4 marks)
- b) With the help of a neat block diagram, design a single point to multi-point optical fibre network. (5 marks)
- c) A fibre-link between Mlolongo and Makindu has been cut and the signal is lost! As a technician working for a local service provider, mentioning the right pieces of equipment to be used, describe how you will detect and repair the fault. (4 marks)
- d) Describe the process of manufacturing an optical fibre (7marks)

QUESTION FIVE (20 MARKS)

- a) Identify the two types of joints in an optical fibre (2 marks)
- b) An 80-km fibre link with a loss of 0.25 dB/km has five connectors in its path and each connector has a loss of 2 dB. Calculate the total loss for the entire link and the factor by which the power reduces by. (4 marks)
- c) Describe the three types of multi-step single mode fibres (6 marks)
- d) Discuss the challenges facing the operation of Internet of Things (IoT) as a modern technology (5 marks)
- e) A receiver has a bandwidth of 10 MHz and operates at 130 °C and has a 50 Ω load. Calculate the thermal noise for this receiver (3 marks)