



MACHAKOS UNIVERSITY

University Examinations 2022/2023 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SECOND SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPT 208: APPLIED OPTICS AND TECHNOLOGY

DATE: 12/4/2023

TIME: 8:30 – 10:30 AM

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

YOU MAY USE:

You may need to use the following constants:

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

$c = 2.998 \times 10^8 \text{ m/s}$, Stefan-Boltzmann constant = $5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$, $\epsilon_0 = 8.85 \times$

$10^{-12} \text{ Nm}^2 \text{ C}^{-2}$, $\mu_0 = 4\pi \times 10^{-7} \text{ T mA}$,

SECTION A

QUESTION ONE (30 MARKS)

- a) Describe the term reflection holography. (3 marks)
- b) Define polarimetry and state how useful it is as an analytical technique.

- (3 marks)
- c) If the refractive indices of the fibre core and cladding are 1.46 and 1.35 respectively. Under what conditions will the light get trapped within the core? (2 marks)
- d) Explain three unique properties of a laser. (6 marks)
- e) If the typical loss in a single-mode fibre is 0.2dB/km, calculate the maximum distance that a 15 dB/m optical signal can be transmitted if a -18dB/m receiver is to be used. (4 marks)
- f) Describe how optical signals can be transmitted through an optical fibre and show how losses can be minimized. (5 marks)
- g) Describe the three dispersion mechanisms (3 marks)
- h) An optical fibre has refractive indices n_1 and n_2 for the core and cladding materials respectively. Show that its numerical aperture (NA) is given by (4 marks)

$$NA = \sqrt{n_1^2 - n_2^2}$$

QUESTION TWO (20 MARKS)

- a) Define the following terms
- i. holography (2 marks)
 - ii. population inversion (2 marks)
- b) Explain the mechanism of population inversion for a three-level energy state system. (6 marks)
- c) Explain the following processes in holography
- (i) Recording the image (3 marks)
 - (ii) Reconstruction of the image (3 marks)
- d) Define multiplexing and identify any four multiplexing techniques for improving the capacity of a single mode fibre (4 marks)

QUESTION THREE (20 MARKS)

- a) Describe the basic operation principle of operation of a polarimeter. (6 marks)
- b) Discuss applications of polarimeters in modern day technology (4 marks)
- c) Highlight four advantages of using optical fibre over copper wires. (4 marks)
- d) Discuss three applications of holography in modern day technology (6 marks)

QUESTION FOUR (20 MARKS)

- a) Describe how an image intensifier works (5 marks)
- b) Discuss the main components of an optical fibre (5 marks)
- c) Describe the 3-step principle of operation of a laser (5 marks)
- d) Using a suitable diagram, describe the operational principle of Hall-effect for measuring magnetic field density (5 marks)

QUESTION FIVE (20 MARKS)

- a) Draw a well-labelled block diagram of a standard laser and describe the properties and roles of each part. (6 marks)
- b) For a gas molecule, show that its average velocity is given by;
$$V = \sqrt{\frac{3KT}{m}}$$
 (4 marks)
- c) Describe the differences between quantum dot and quantum well lasers. (6 marks)
- d) Identify any four pumping mechanisms of a laser (4 marks)