



MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR
BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPH 212: APPLIED OPTICS AND TECHNOLOGY

DATE: 16/03/2022

TIME: 8:30-10:30 AM

INSTRUCTIONS TO CANDIDATES

Answer QUESTION ONE and ANY OTHER TWO questions.

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

YOUMAYUSE:

You may need to use the following constants:

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

10^8 m/s , Stefan-Boltzmann constant= $5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$, $\epsilon_0 = 8.85 \times 10^{-12} \text{ Nm}^2 \text{ C}^2$,

$\mu_0 = 4\pi \times 10^{-7} \text{ TmA}$,

QUESTION ONE

- a) Describe any three methods causing radiation-matter interaction (6 marks)
- b) If the refractive indices of the fibre core and cladding are 1.46 and 1.35 respectively, under what conditions will the light be trapped within the core? (2 marks)
- c) Define the properties of a coherent laser. (3 marks)
- d) If the typical loss in a single-mode fibre is 0.2dB/km, calculate the maximum distance that a 15dBm optical signal can be transmitted if a -18dBm receiver is to be used. (2 marks)
- e) State Stefan-Boltzmann law of radiation. (3 marks)
- f) Using a clearly labelled figure, describe the three basic components of a quantum dot laser. (6 marks)
- g) Define an X-ray image intensifier (1 mark)
- h) Explain why the Avalanche photodiode has a higher sensitivity than the PIN photodiode (2 marks)
- i) Describe the three dispersion mechanisms (3 marks)
- j) State Huygens's principle (2 marks)

QUESTION TWO

- a) Three light beams are emitting at 578nm, 601nm and 632nm at 3000K, 4000K and 5000K temperatures.
- (i) Calculate the intensities of the three beams. (3marks)
- (ii) Sketch a graph of intensity vs wavelengths for the above emissions. (3 marks)
- b) For a gas molecule, show that its average velocity is given by;
- $$V = \sqrt{\frac{3KT}{m}} \quad (4 \text{ marks})$$
- c) Describe the three types of interference of light. (5 marks)
- d) Name any five types of lasers (5 marks)

QUESTION THREE

- a) State Beer-Lambert's law and plot its profile (4 marks)
- b) Discuss the main components of an optical fibre (5 marks)
- c) Define a laser and describe its principle of operation (5 marks)
- d) Describe the operational principle of a head-on detection base on Hall-effect (6 marks)

QUESTION FOUR

- a) Describe the basic principle of operation of a polarimeter. (6 marks)
- b) Discuss applications of polarimeters in modern day technology (4 marks)
- c) With the help of a neat block diagram, design a simple point to point optical fibre-link. (6 marks)
- d) 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)

QUESTION FIVE

- a) Identify the advantages of using optical fibre transmissions over copper. (5 marks)
- b) What is population Inversion? Explain the mechanism of Population inversion for three level & four level energy state system. (5 marks)
- c) Show that the numerical aperture of an optical fibre is given by;
$$NA = \sqrt{(\eta_1^2 - \eta_2^2)}$$
 (5 marks)
- d) Define multiplexing and identify any four multiplexing techniques for improving the capacity of a single mode fibre. (5 marks)