TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS 2016/2017

FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 2504:QUANTUM ELECTRONICS

END OF SEMESTER EXAMINATIONS

SERIES: MAY, 2016

TIME: 2 HOURS PAPER 1

INSTRUCTIONS:

1. You should have the following for this examination:
   - Answer booklet
   - Non-Programmable Scientific calculator
2. This paper consists of **FIVE** questions
3. Answer Question ONE and any other T**WO** Questions.
4. Table of physical constants is given at the end of the question paper
5. Do not write on the question paper.

5. This paper consists of FOUR printed pages.

Question ONE

(a) (i) Explain the concept of electromagnetic modes in relation to a planer optical waveguide.

(ii) Discuss the modification that may be made to electromagnetic mode theory in a planer waveguide in order to describe optical propagation in a cylindrical fiber.

(iii) A multimode step index fiber has a relative refractive index difference of 1% and a core refractive index of 1.5. The number of modes propagating at a wavelength of 1.3μm is 1100. Estimate the diameter of the fiber core.

(10 marks)

(b) (i) Outline **FIVE** reasons for the adoption of the materials and devices used for photo detection in optical fiber communications.

(ii) Discuss in detail the p-i-n photodiode with regard to performance and compatibility requirements in photo detections.

(iii) When 800 photons per second are incident on a p-i-n photodiode operating at a wavelength of 1.3μm they generate on average 550 electrons per second which are collected. Calculate the responsivity of the device. **(10 marks)**

(c) Show that a particle moving in infinite potential well is represented by a standing wave. **(10 marks)**

Question TWO

(a) Describe with the aid of simple ray diagrams:

(i) The multimode step index fiber.

(ii) The single mode step index fiber.

(iii) Compare the advantages and disadvantages of these two types of fiber for use as an optical channel.

(10 marks)

(b) (i) Briefly discuss with the aid of a suitable diagram what is meant by the acceptance angle for an optical fiber.

(ii) The cladding of an optical fiber has **THREE** main functions state these functions.
(7 marks)

(c) A multimode step index fiber with a core diameter of 80μm and a relative index difference of 1.5% is operating at a wavelength of 0.85μm. If the core refractive index is 1.48, estimate:

(i) The normalized frequency for the fiber
(ii) The number of guided modes

(3 marks)

Question THREE

(a) (i) Describe, with the aid of suitable diagrams, the major structures utilized in the fabrication of single mode injection lasers.

(ii) Give **THREE** reasons for the current interest in devices of (i).

(7 marks)

(b) (i) Explain the term solid-state laser.

(ii) With the aid of a well labelled diagram, briefly explain the design structure and operation of a ruby laser.

(10 marks)

(c) Calculate the ratio of the stimulated emission rate to the spontaneous emission rate for an incandescent lamp operating at a temperature of 1000K. Assume that the average operating wavelength is 0.5μm. **(3 marks)**

Question FOUR

(a) Outline the advantages and drawbacks with the use of the RAPD as a detector for optical fiber communications. **(5 marks)**

(b) A photodiode has a quantum efficiency of 65% when photons of energy 1.5×10^{-19}J are incident upon it.

(i) Determine the wavelength at which the photodiode is operating?

(ii) Calculate the incident optical power required to obtain a photocurrent of 2.5μA when the photodiode is operating.

(4 marks)

(c) Given that the binding energy of a hydrogen atom is E = -12eV, obtain the orbital radius and velocity of the electron in a hydrogen atom. **(5 marks)**

(d) In single-mode fibers, the total dispersion is composed of **THREE** components. State and explain these components. **(6 marks)**

Question FIVE

(a) (i) Discuss with the help of a sketch, the mechanism of optical feedback to provide oscillation and hence amplification with the laser. Indicate how this provides a distinctive spectral output from the device.

(ii) The longitudinal modes of a gallium arsenide injection laser emitting at wavelength of 0.87μm are separated in frequency by 278GHz. Determine the length of the optical cavity and the number of longitudinal modes emitted. The refractive index of gallium arsenide is 3.6.

(11 marks)

(b) State THREE applications of quantum electronics.

(3 marks)

(c) When the optical power launched into an 8kM length of fiber is 120µW, the mean optical power at the fiber output is 3µW. Determine:

(i) The overall single attenuation or loss is decibels through the fiber assuming there are no connectors or splices.

(ii) The signal attenuation per 1 kilometer for the fiber.

(iii) The overall signal attenuation for a 10km optical link using the same fiber with splices at 1km intervals, each giving an attenuation of 1dB.

(iv) The numerical input/output power ratio in (iii).

(6 marks)