MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 529: OPTICAL FIBER

DATE: **TIME:**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Explain the implication of the following terms to optoelectronics (6 marks)

i. Absorption

ii. Band-gap

iii. Emission

b) Given that the radiative lifetime $\tau_r = 10^9/N$ s, where N is the semiconductor doping in cm^{-3} and the non-radiative lifetime τ_{nr} is equal to 10^{-7} s. Find the cutoff frequency of an LED having a doping of 10^{19} cm^{-3}. (4 marks)

c) Describe using appropriate illustration how a photodetector converts light signal into electrical signal. Include the PN junction operation (8 marks)

d) Using appropriate energy diagram, explain the types of band gap, their implication on various uses. Give example of application citing the reason for the type of application (6 marks)

e) The radiative and non radiative recombination life times of minority carriers in the active region of a double heterojunction LED are 60 nsec and 90 nsec respectively and the peak emission wavelength of Silicon is 870 nm and the drive currect is 40 mA. (6 marks)

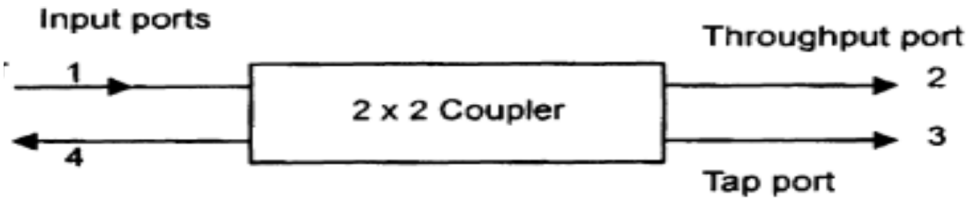
i. Determine the total carrier recombination life time

ii. optical power generated internally

QUESTION TWO 20 MARKS

a) A particular type of optical fibre demonstrated a loss of 40% in a length of 7km. In a 35km link using this type of fibre the required output power is 0.2μW. Determine the minimum possible launched power assuming no joint losses, margin and penalties. (7 marks)

b) Calculate the output power at each port in the coupler shown if the excess loss is 2dB, Directionality loss is -50dB and a splitting ratio of 4:1. The input power is 40μW (7 marks)



c) A step-index fiber has a core index of refraction of 1.425. The cut-off angle for light entering the fiber from air is found to be 8.50^{o}. Determine (6 marks)

i) the numerical aperture of the fiber
ii) the index of refraction of the cladding of this fiber
iii) the new numerical aperture and cut-off angle if the fiber were submersed in water

QUESTION THREE (20 MARKS)

a) Explain 3 sources of noise and disturbances in optical devices (6 marks)

b) Explain four advantages and four disadvantages of LED (8 marks)

c) Explain condition necessary to sustain lasing (6 marks)

QUESTION FOUR 20 MARKS

a) Explain four parameter used in measurement of performance of a photodiode used as a receiver (8 marks)

b) The following parameters were chosen for a long haul single mode optical fiber system operating at 1.3μm. (8 marks)

- Mean power launched from laser = 3dBm
- Cabled fiber loss = 0.4 dB/km
- Splice loss = 0.1 dB/km
- Connector loss at transmitter and receiver = 1 dB each
- Mean power required at the APD
  - *a)* When operating at 35Mbps(BER = 10^{-9}) -55 dBm
  - *b)* When operating at 400Mbps(BER = 10^{-9}) -44 dBm
- Required safety margin = +7 dB

Determine:

i. Maximum possible link length without repeaters when operating at 35Mbps. It may be assumed that there is no dispersion-equalization penalty at this rate.
ii. Maximum possible link length without repeaters when operating at 400Mbps.
iii. The reduction in the maximum possible link length without repeaters of (ii) when there is dispersion-equalization penalty of 1.5dB.

c) An electron of a hydrogen atom falls from the M (12.1 eV) to the L (10.2 eV) shell. Determine the wavelength of the radiated light (4 marks)

QUESTION FOUR 20 MARKS

a) Derive the following expression for LED (10 marks)

(i) internal quantum efficiency
(ii) internally generated optical power
*(iii)*external efficiency

b) Explain five losses in an LED. Show the appropriate relations used to calculate the respective efficiencies (10 marks)

Physical Constants

Avogadro's number	$N_A = 6.02 \times 10^{+23}$ atoms per gram molecular weight
Boltzmann's constant	$k = 1.38 \times 10^{-23}$ J/K $= 8.62 \times 10^{-5}$ eV/K
Electronic charge (magnitude)	$e = 1.60 \times 10^{-19}$ C
Free electron rest mass	$m_0 = 9.11 \times 10^{-31}$ kg
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H/m
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-14}$ F/cm $= 8.85 \times 10^{-12}$ F/m
Planck's constant	$h = 6.625 \times 10^{-34}$ J-s $= 4.135 \times 10^{-15}$ eV-s
	$\frac{h}{2\pi} = \hbar = 1.054 \times 10^{-34}$ J-s
Proton rest mass	$M = 1.67 \times 10^{-27}$ kg
Speed of light in vacuum	$c = 2.998 \times 10^{10}$ cm/s
Thermal voltage ($T = 300$ K)	$V_t = \frac{kT}{e} = 0.0259$ V
	$kT = 0.0259$ eV

Material	Index of Refraction (n)
Vacuum	1.000
Air	1.000277
Water	1.333333
Ice	1.31
Glass	About 1.5
Diamond	2.417