Kafrelsheikh University
Faculty of Engineering
Department of **Electrical Eng.**
Subject: Optoelectronics , 3rd year
Examiner: Dr. Bedir B. Yousif

Date: 9/6 /2019
Time allowed: 3 hours
Full mark: **100 Mark**
Finalterm Exam: Two pages
Academic Number: **ECE3208**

- **Course ILOS**

Field	National Academic Reference Standards (NARS)			
	Knowledge & Understanding	**Intellectual Skills**	**Professional Skills**	**General Skills**
Academic standards that the course contribute in achieving it	a1, a2, a3, a4, a5	b1, b2, b3	c1, c2, c3, c4, c5, c6	d1, d2, d3

Solve the following questions and any missing data could be reasonably assumed :-

Question One: (a1,a2,a3,b1,b2,c1,c2,c3,c4) **(50 Mark)**

a. What is the difference between: i- Direct and indirect bandgap semiconductors.
ii- LASER and Avalanche photodiode (6 Marks)

b. The coated mirror reflectivity at either end of the 350 μm long optical cavity of an injection laser is 0.5 and 0.65. At normal operating temperature the threshold current density for the device is 2×10^3 A cm^{-2} and the gain factor β is 22×10^{-3} cm A^{-1}. Estimate the loss coefficient in the optical cavity. (6 Marks)

c. A ruby laser contains a crystal of length 4 cm with a refractive index of 1.78. The peak emission wavelength from the device is 0.55 μm. Determine the number of longitudinal modes and their frequency separation. (6Marks)

d. Briefly explain the differences between i. Two level, three level and four level system for lasing emission. (6 mark)

e. Define: Heterojunction and homojunction of p–n diode– Laser modes- population inversion - quantum efficiency of LASER diode and photodetector- Stimulated and spontaneous emission of light. (6 mark)

f. Calculate the PIN photodiode sensitivity if it has a quantum efficiency of 80% at operating Wavelength 1300 nm, signal to noise ratio 22 dB, and system bit rate 25 Gbps. (7 mark)

g. Drive an expression of the threshold medium gian of Fabry Perot resonator? (6 mark)

h. Calculate the photocurrent of photodetector that has absorption coefficient of $5 \times 10^5\ cm^{-1}$,the width of absorption region is 500 μm, and reflection of surface is 0.4 at the photons rate $3 \times 10^{11}\ photons\ per\ second$. (7 mark)

STIFFNESS MATRIX K21

0.	0.	0.	0.	-4.	-5.	0.	0.	0.	0.	0.	0.
0.	-25.	0.	0.	-5.	-6.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	-4.	5.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	5.	-6.	0.	-25.

STIFFNESS MATRIX K22

3.6	4.8	.0	.0
4.8	31.4	.0	.0
.0	.0	3.6	-4.8
.0	.0	-4.8	31.4

The data file in case of banded matrix

```
14,8,0,12,2,2,1,1,1000.
0.05,0.1
1,1,1,3,2,1,3,5,3,1,5,6,4,1,2,4,5,1,2,3,6,1,4,5,7,1,2,5,8,1,3,4
9,1,3,7,10,1,5,8,11,2,1,7,12,2,1,2,13,2,4,6,14,2,6,8
1,0.,4.,2,3.,8.,3,3.,4.,4,6.,8.,5,6.,4.,6,9.,4.,7,0.,0.,8,9.,0.
1,1,1,1,1,1,1,1,1,1,1,0,0,0,0
```

Result file

BANDED MATRIX

23.9	9.6	-7.2	-9.6	-16.7	.0	.0	.0
37.8	-9.6	-12.8	.0	.0	.0	.0	.0
27.5	4.8	.0	.0	-16.7	.0	-3.6	4.8
31.7	.0	-12.5	.0	.0	4.8	-6.4	.0
40.5	9.6	-3.6	-4.8	-16.7	.0	.0	.0
25.3	-4.8	-6.4	.0	.0	.0	.0	.0
27.5	-4.8	.0	.0	-7.2	9.6	.0	.0
31.7	.0	-12.5	9.6	-12.8	.0	.0	.0
40.5	-9.6	-16.7	.0	.0	.0	.0	.0
25.3	.0	.0	.0	.0	.0	.0	.0
23.9	-9.6	.0	.0	.0	.0	.0	.0
37.8	.0	.0	.0	.0	.0	.0	.0

The band width will be (3+1)*2=8
Then, the size of [k11] = 12*8 instead 12* 12

Question Two: (a4,a5 ,b3, c5,c6) **(50 Mark)**

a. Compare the approximate radiative minority carrier lifetimes in gallium arsenide and silicon when the minority carriers are electrons injected into the p-type region which has a hole concentration of 10^{18} cm^{-3}. The injected electron density is small compared with the majority carrier density, if the recombination coefficient B_r for Si is $1.79 \times 10^{-15}\ cm^3S^{-1}$and GaAs is $7.21 \times 10^{-10}\ cm^3S^{-1}$. (5 mark)

b. A GaAs injection laser has an optical cavity of length 250 μm and width 100 μm. At normal operating temperature the gain factor $\bar{\beta}$ is 21×10^{-3} A cm^{-3} and the loss coefficient A per cm is 10. Estimate the threshold current density and hence the threshold current for the device. It may be assumed that the cleaved mirrors are uncoated and that the current is restricted to the optical cavity. The refractive index of GaAs may be taken as 3.6. (5 mark)

c- The quantum efficiency of a particular silicon APD is 80% for the detection of radiation at a wavelength of 0.9 μm. When the incident optical power is 0.5 μW, the output current from the device (after avalanche gain) is 11 μA. Determine the multiplication factor of the photodiode under these conditions. (5 mark)

d. What are the major requirements for an optical fiber communications emitters and detectors? (5 mark)

e. A photodetector has a quantum efficiency of 80% at 1000 nm. A radiation of optical power 0.01 watt/m at this wavelength is incident on the device which has a receiving area of 1 mm^2 . The detector has a dark current of 5 nA and a shunt resistance of 10 ohms. If the bandwidth of operation is 100 MHz, calculate the power SNR of the detector. (8 mark)

f. AlGaInAs/InP laser, operating at 1550 nm for absolute temperature 20000 K. a- Calculate the ratio between Einstein's stimulated emission coefficient to spontaneous emission coefficient? (5 mark)

g. - A photodiode has a quantum efficiency of 65% when photons of energy 1.5×10^{-19} J are incident upon it. (5 mark)

(i) At what wavelength is the photodiode operating?

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

h. Design a Fabry-Perot cavity for a ruby laser contains a crystal of length L cm with a refractive index of n. The peak emission frequency from the device is 545.45 THz and the number of longitudinal modes is 3×10^5 . Determine n, L if the separation wavelength is 4 nm. (5 mark)

i. What are the main performance metrics of LASER and Photodetector? (7 mark)

Best wishes of success

Dr. Bedir yousif