UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2009/2010

SUBJECT NAME	: OPTICAL COMMUNICATION SYSTEM
SUBJECT CODE	: BEP 4253
COURSE	: 4 BEE
DATE OF EXAM	: NOVEMBER 2009
DURATION	: 3 HOURS
INSTRUCTION	: ANSWER ALL QUESTIONS

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Q1 (a) When light waves propagate into the optical fiber, phase and group velocity exist. With the aid of diagrams, differentiate between these **TWO (2)** velocities.

(6 marks)

(b) Fiber dispersion limits the data rate that can be transmitted in the optical fiber. Distinguish the difference between these **THREE (3)** types of dispersion.

(i) Material dispersion
(ii) Waveguide dispersion
(iii) Intermodal dispersion

(6 marks)

(c) Consider an optical link consisting of a 5 km long step index fiber with core index $n_1 = 1.49$ and relative index difference $\Delta = 1\%$

(i) Find the delay difference at the fiber end between the slowest and fastest modes.
(ii) Find the rms pulse broadening caused by intermodal dispersion
(iii) Calculate the maximum bit rate B_T that can be transmitted over the fiber without significant errors, where $B_T = \frac{0.2}{\sigma_{step}}$
(iv) Assuming the maximum bit rate equals the bandwidth, what is the bandwidth-distance product of this fiber?

(8 marks)

Q2 (a) It is known that lasers do not produce power efficiently because most of the time they consume and waste a lot of electricity. Describe the feature of lasers that makes them so special despite this energy inefficiency?

(4 marks)

(b) Relate **THREE (3)** usage of a laser in real life applications.

(6 marks)

(c) Semiconductor lasers will only operate if the operating current exceeds the threshold current. Otherwise, they will not emit light. Point out why is that so? Support your answer with a diagram.

(4 marks)

(d) Outline the advantage of a Distributed Feedback Laser (DFB) laser over a Fabry Perot (FP) laser in term of mode of light transmitted?

(3 marks)

(e) When fabricating mirrors for lasers for a mass production, it is easier to

fabricate mirrors for Vertical Cavity Surface Emitting Laser (VCSEL) than for DFB or FP laser. Deduce why is that so?

(3 marks)

Q3 (a) The performance of a photodiode is often characterized by its responsivity. This parameter has a lower cutoff frequency and a higher cutoff frequency. Explain what these cutoff frequencies are.

(4 marks)

(b) Differentiate with the aid of diagram between pin photodiode and avalanche photodiode in terms of structure and energy band diagram.

(6 marks)

(c) Performance of a receiver is very much related to the signal to noise ratio (SNR) of incoming light. The higher the SNR, the better the performance of the system. Describe

(i) Thermal noise
(ii) Shot or quantum noise

(4 marks)

(d) A germanium photodiode incorporated into an optical fiber receiver working at a wavelength of 1.55μm has a dark current of 500nA at the operating temperature. When the incident optical power at this wavelength is 1μW and the responsivity of the device is 0.6 A/W, shot noise dominates the receiver. Determine the SNR in dB at the receiver when post detection bandwidth is 100 MHz.

(6 marks)

Q4 (a) With the aid of a suitable energy band diagram, demonstrate how an Erbium Doped fiber Amplifier (EDFA) works.

(6 marks)

(b) There are **THREE (3)** possible configurations of an EDFA: codirectional pumping, counter directional pumping and dual pumping. Distinguish between these configurations in term of structure and advantage or disadvantage.

(9 marks)

(c) The main issue with an EDFA is that the gain is not flat over a certain frequency range. Propose a technique that can overcome the shortcoming.

(5 marks)

Q5 (a) Propose and sketch a DWDM ring network which employs **FOUR (4)** DWDM wavelengths and Optical Add Drop Multiplexers (OADMs).

(7 marks)

(b) The following parameters are established for a long haul single mode optical system operating at a wavelength of 1.3um.

Mean power launched from the laser transmitter	-3 dBm
Cabled fiber loss	0.4dB /km
Splice loss	0.1dB/km
Connector losses at the transmitter and receiver	1dB each
Mean power required at the APD receiver:	
When operating at 35Mbit/s (BER 10-9)	-55dBm
When operating at 44Mbit/s (BER 10-9)	-44dBm
Required safety margin	7 dB

Estimate:

Assuming that there is no-dispersion-equalization penalty,

(i) The maximum possible link without repeaters when operating at 35Mbit/s.

(ii) The maximum possible link without repeaters when operating at 44Mbit/s

Assuming that there is a dispersion-equalization penalty of 1.5 dB,

(i) The maximum possible link without repeaters when operating at 44Mbit

(9 marks)

(c) With the aid of a suitable diagram, describe the operation of an Optical Cross Connect (OXC).

(4 marks)