MST SAMPLE PAPER

Section A

A1. Which one of the following statement is correct?
- (a) Step index multimode fibre has the lowest modal dispersion.
- (b) Graded index multimode fibre has the lowest modal dispersion.
- (c) Step index multimode fibre has the highest modal dispersion.
- (d) Single mode fibre has no dispersion.

A2. Attenuation in an optical fibre is mainly caused by:
- (a) Reflection and refraction.
- (b) Misalignment and Bending.
- (c) Total internal reflection.
- (d) Scattering and absorption.

A3. A component in an optical fibre structure which prevents the fibre from damage is the:
- (a) Cladding.
- (b) Nylon jacket.
- (c) Core and cladding.
- (d) Core.

A4. The commonly used non-coherent light source in an optical communication link is:
- (a) APD
- (b) ILD
- (c) LED
- (d) PIN

A5. Which of the following factors does not affect the bandwidth of an optical communication link?
- (a) Fibre material dispersion.
- (b) Fibre loss.
- (c) Fibre modal dispersion.
- (d) Optical transmitter rise time.

A6. The main disadvantage of an ILD light source in an optical fibre system is:
- (a) Shorter life span.
- (b) Higher output power
- (c) Smaller spectral width
- (d) Less material dispersion.

A7. In a 2.2 Km optical fibre link with operating wavelength of 1550 nm, which one of the following optical fibre type would have the lowest dispersion?
(a) Graded step index multimode.
(b) Graded index multimode.
(c) Step index multimode.
(d) Single mode step index.

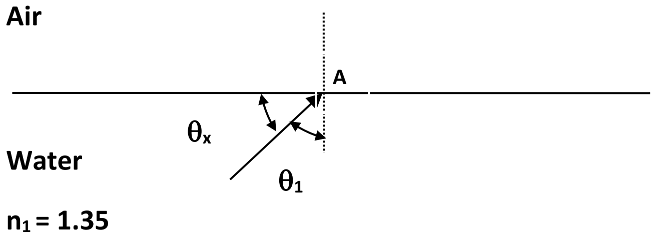
A8. The most accurate loss measurement technique in an optical fibre is:
(a) Cutback technique.
(b) Insertion loss technique.
(c) OTDR technique.
(d) Stimulated technique

A9. An optical fibre core refractive index will always be:
(a) less than the refractive index of the cladding.
(b) equal to the refractive index of the cladding.
(c) greater than the refractive index of the cladding.
(d) inversely proportional to the refractive index of the cladding.

A10. The communication signals on a piece of optical fibre are:
(a) in the form of holes.
(b) current and voltage.
(c) in the form of light energy.
(d) in the form of electrons.

Section B

B1. A light beam travels from water (n_1 = 1.35) to air (n_2 = 1.0) with an incidence angle θ_1 as shown in figure below:



(a) Calculate the critical angle for water at water-air interface at point A. (4 marks)
(b) If $\theta_1 = 40^0$, sketch the light beam path, after striking water-air interface at point A. State clearly if TIR will occur and give reasons to support your answer. (10 marks)
(c) Calculate the range of angles for θ_x for total internal reflection to occur at point A. (6 marks)

B2. (a) Sketch the refractive index profiles of step-index multimode fibre & single mode fibre. Indicate clearly the core radius (a), core refractive index (n_1) & cladding refractive Index (n_2) in the sketch. (8 marks)
(b) A multimode step-index fibre with cladding refractive index of 1.38, is designed to have an acceptance cone angle of 75^0 and operates at λ = 1310nm. . (7 marks)
(i) Find its acceptance angle, numerical aperture and core refractive index.
(ii) If the core diameter of the step-index fibre is 50μm, calculate the number of modes in the fibre.
(iii) Find the required core diameter if the number of modes in the fibre is to be further reduced and become single mode operation

B3. (a) Name the three types of dispersion occurred in optical fibre. (3 marks)
(b) The optical fibre link is designed to achieve **maximum** link length performance, which type of optical source, detector & wavelength do you recommend ? (6 marks)
(c) The optical fibre link is designed to achieve **maximum** bandwidth performance, which type of optical source, fibre & wavelength do you recommend ? (6 marks)
Give reasons to support your answers in (b) & (c).

B4. 5. A PIN photodiode on average generate one electron-hole pair per two incident photons at a wavelength of 900nm. If 27.8μw of optical light incident on the photodiode and assuming that all the electrons are collected at the photodiode terminal.

(a) Calculate the maximum possible bandgap energy in eV. (4 marks)
(b) Calculate the quantum efficiency of the photodiode. (4 marks)
(c) Estimate the Photon rate and Electron rate. (6 marks)
(d) Calculate its responsivity at 900nm. (6 marks)

**** END OF PAPER ***

ANSWER

Section A

A1.	-	(c)
A2.	-	(d)
A3.	-	(b)
A4.	-	(c)
A5.	-	(b)
A6.	-	(a)
A7.	-	(d)
A8.	-	(a)
A9.	-	(c)
A10.	-	(c)

Section B

B1.

Critical angle the water-air interface at A

$1.35 \sin(\theta_c) = 1.0 \sin 90^0$

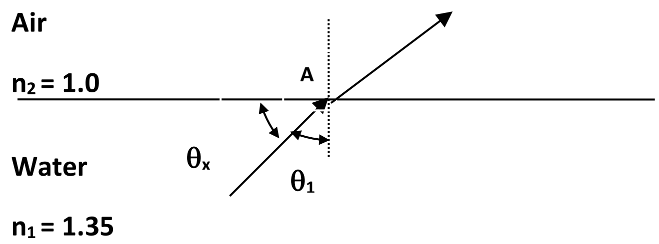
$\theta_c = 47.79^0$

TIR will not occur. For TIR to happen, there are two conditions:

i) Light must travel from denser medium to less dense medium

ii) Angle of incidence must be greater than critical angle

Since angle of incidence (40^0) is less than critical angle (47.79^0), light is refracted into the air.



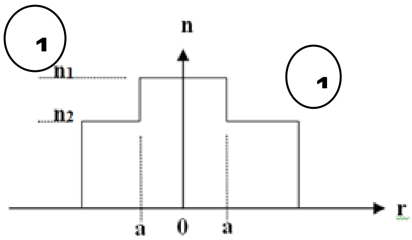
For TIR to occur, $\theta_i = \theta_1 > \theta_c\,(= 47.79^0)$.

Hence $\theta_x < 90^0 - 47.79^0 = 42.21^0$

The range is $0^0 < \theta_x < 42.21^0$

B2.

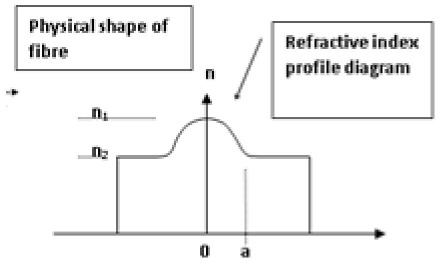
(i) Step-index multimode fibre



n_1, n_2, and *a* labelling – 3 marks

Correct shape of the profile – 1 marks

(ii) Graded index multimode fibre



n_1, n_2, and *a* labelling

– 3 marks

Correct shape of the profile

– 1 marks

$$n(r) = n_1\sqrt{1-2\Delta(\frac{r}{a})^{\alpha}} \qquad \text{and}$$

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} = \frac{1.46^2 - 1.38^2}{2x1.46^2} = 0.0533$$

$$n(r) = n(r = 25\mu m) = 1.46\sqrt{1-2(0.0533)(\frac{25}{31})^2} = 1.408$$

$$\sigma = \frac{n_1 L\Delta^2}{\sqrt{48}c} = \frac{1.46\times 2\times 10^3\times 0.0533^2}{\sqrt{48}\times 3\times 10^8} = 3.99\text{ ns}$$

$$BW = \frac{0.35}{\sigma} = \frac{0.35}{3.99\times 10^{-9}} = 87.72(MHz)$$

B3

Name the three types of dispersion occurred in optical fibre :

1. Intermodal (modal) dispersion.

2. Material dispersion.

3. Waveguide dispersion.

Optical fibre link designed to achieve **maximum** link length performance, type of optical source, detector & wavelength recommended :

Optical source : ILD (High output power)

Optical detector : APD (High sensitivity)

Optical wavelength : 1310nm (Low loss window)
or 1550nm (Low loss window)

Optical fibre link designed to achieve **maximum** bandwidth performance, type of optical source, fibre & wavelength recommended :

Optical source : ILD (Narrow spectral width and resulted low material dispersion)

Optical fibre : Single mode fibre (Remove modal dispersion and resulted low dispersion)

Optical wavelength : 1310nm (Minimum material dispersion which cancelled off waveguide dispersion and resulted almost zero dispersion)

B4.

. 1 electron-hole pair generated from 2 incident photons, $\lambda = 900$ nm

(a) Max possible bandgap energy : $E_g = \dfrac{1.24}{\lambda} = \dfrac{1.24}{0.9} = 1.38(eV)$

(b) Quantum efficiency $\eta = 1 / 2 = 0.5 = 50\%$

(c) If $P_o = 27.8$ μw,

Photon rate : $r_p = P_o / (hc/\lambda) = P_o\lambda / hc$
$= (27.8 \times 10^{-6})(900 \times 10^{-9}) / [(6.626 \times 10^{-34})(3 \times 10^{8})]$
$= 1.252 \times 10^{14}$ (photons / sec)

Electron rate : $r_e = \eta r_p = (0.5)(1.252 \times 10^{14}) = 6.26 \times 10^{13}$ (electrons / sec)

(d) Responsivity :

$R = \eta\lambda e / hc = [(0.5)(900 \times 10^{-9})(1.602 \times 10^{-19})] / [(6.626 \times 10^{-34})(3 \times 10^{8})]$
$= 0.362$ (A/W)