Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SIXTH SEMESTER B.TECH. (E & C) DEGREE END SEMESTER EXAMINATION
APRIL/MAY 2019
SUBJECT: OPTICAL FIBER COMMUNICATION (ECE - 4011)

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates

- Answer **ALL** questions.
- **h = 6.626 x 10^{-34} Js , c = 2.998 x 10^{8} m/s , e or q = 1.602 x 10^{-19} C**
- Missing data may be suitably assumed.

1A. The velocity of light in the core of a step index fiber is 2.04×10^{8} m s^{-1}, and the critical angle at the core–cladding interface is 74°. Determine i) the core's refractive index, ii) numerical aperture and iii) the acceptance angle for the fiber in air, assuming it has a core diameter suitable for consideration by ray analysis iv) number of modes supported by this fiber with a core diameter of 80 μm and operating wavelength of 850 nm.

1B. Describe with the aid of simple ray diagrams:
(i) the multimode step index fiber (ii) the single-mode step index fiber
Compare the advantages and disadvantages of these two types of fiber for use as an optical channel.

1C. With the help of a neat and labelled diagram for WDM PON architecture, explain the upstream transmission.

(4+3+3)

2A. Explain stimulated Brillouin scattering and determine the threshold optical power for SBS for a long SM fiber with an attenuation 0.18 dB/km, core diameter of 9 μm and operating at a wavelength of 1.55μm with laser source bandwidth of 550 MHz.

2B. The light output from the GaAs LED is coupled into a step index fiber with a numerical aperture of 0.3, a core refractive index of 1.45 and a diameter larger than the diameter of the device.

i. Calculate the optical power emitted into air as a percentage of the internal optical power for the device when the transmission factor at the crystal–air interface is 0.75. The refractive index of GaAs may be taken as 3.6.
ii. When the optical power generated internally is 65% of the electric power supplied, calculate the external power efficiency.
iii. Calculate the coupling efficiency into the fiber when the LED is in close proximity to the fiber core.
iv. Calculate the optical loss in decibels, relative to the power emitted from the LED, when coupling the light output into the fiber.
v. Calculate the loss relative to the internally generated optical power in the device when coupling the light output into the fiber (assuming there is a small air gap between the LED and the fiber core).

(5+5)

3A. An optical amplifier operating at a signal wavelength of 1.3 μm, with an optical bandwidth of 700 GHz. This device has a spontaneous emission factor of 1.5, the mode number is equal to 2 and the ASE noise signal power at the output of the amplifer is 30.45 μW. Determine : i) the gain (in dB) of the amplifier, ii) the noise figure (in dB) of the amplifier and iii) the OSNR (in dB) at the output of the amplifier if the received signal power is 4 μW.

3B. Describe the approaches to achieve flattened gain response for an EDFA. Compare EDFA and SOA.

(5+5)

4A. With neat and labelled diagrams, describe the operation of APD photodiode. Determine the multiplication factor of an APD photodiode if it has responsivity of 0.681 AW^{-1} and when the incident optical power is 0.75 μW, the output current from the device (after avalanche gain) is 15 μA.

4B. Define the quantum efficiency and the responsivity of a photodetector. Derive an expression for the responsivity of an intrinsic photodetector in terms of the quantum efficiency of the device and the wavelength of the incident radiation. Determine the wavelength at which the quantum efficiency and responsivity are equal. Sketch the responsivity vs wavelength for an ideal photodiode and a typical photodiode.

(5+5)

5A. An optical fiber system is to be designed to operate over a 10 km length without repeaters. The rise times of the chosen components are:

LED	3.045 ns
Fiber (intermodal)	0.7 ns km^{-1}
Fiber (intramodal)	0.2 ns km^{-1}
APD	1 ns

From system rise time considerations, estimate the maximum bit rate that may be achieved on the link when using an NRZ and RZ format. Justify your choice of format based on the result obtained.

5B. An edge-emitting LED operating at a wavelength of 1310 nm launches −22 dBm of optical power into a single-mode fiber pigtail. The pigtail is connected to a single-mode fiber link which exhibits an attenuation of 0.4 dB/km at this wavelength. In addition, the splice losses on the link provide an average loss of 0.05 dB/km. The transmission rate of the system is 280 Mbit/s so that the sensitivity of the p–i–n photodiode receiver is −35 dBm. Penalties on the link require an allowance of 1.5 dB and a safety margin of 6 dB is also specified. The connector losses at the LED transmitter and p–i–n photodiode receiver are each 1 dB.

i) Design a link for above given specifications and draw a labelled diagram illustrating this configuration.

ii) Is this system loss limited or dispersion limited? Briefly explain your reasoning.

iii) Calculate the distance over which the link will operate, without using any repeaters.

(5+5)