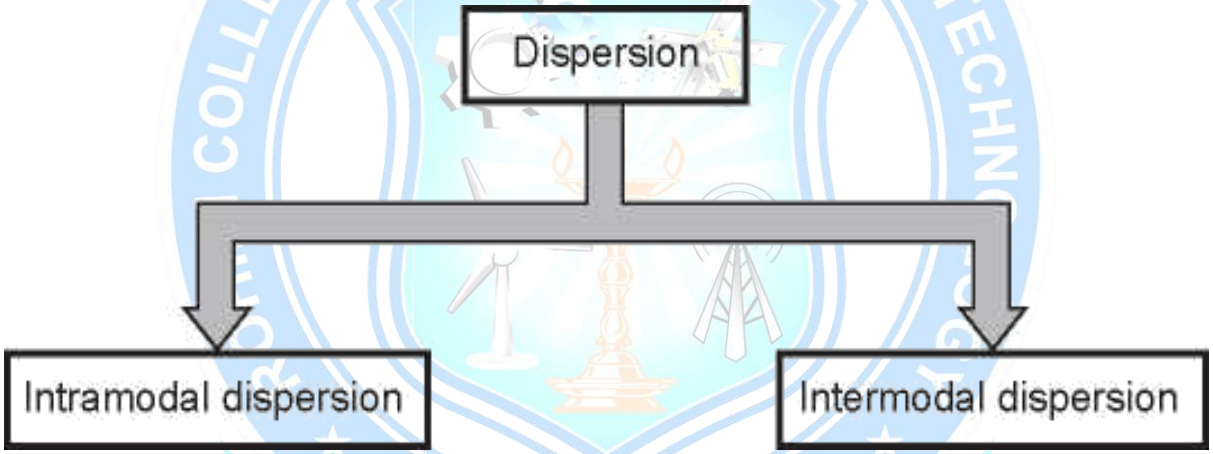
2.5 Signal Dispersion

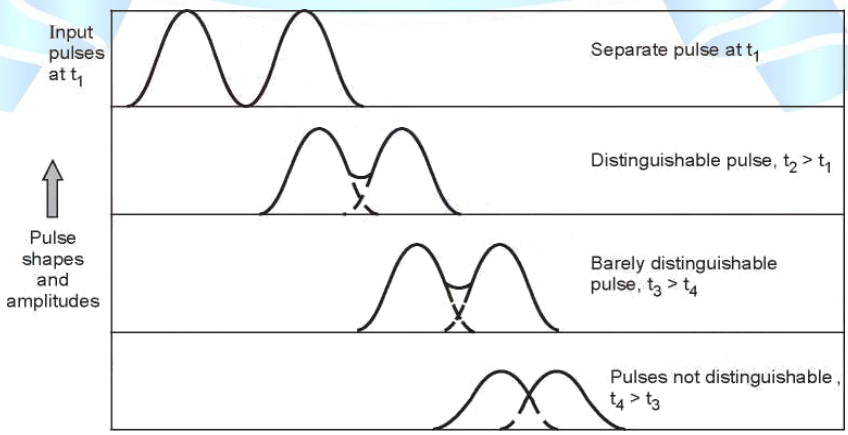
- The pulse gets distorted as it travels along the fiber lengths. Pulse spreading in fiber is referred as **dispersion.** Dispersion is caused by difference in the propagation times of light rays that takes different paths during the propagation. The light pulses travelling down the fiber encounter dispersion effect because of this the pulse spreads out in time domain.
- Dispersion limits the information bandwidth. The distortion effects can be analyzed by studying the group velocities in guided modes.
- In an optical fiber, the dispersion effects can be explained on the basis of group velocities of guided modes. The dispersion can be catergorized into two types as shown in Fig



1. Material/chromatic dispersion
2. Waveguide dispersion
3. Group velocity / modal dispersion

Information Capacity Determination

- Dispersion and attenuation of pulse travelling along the fiber is shown in Fig



- after travelling some distance, pulse starts broadening and overlap with the neighbouring pulses. At certain distance the pulses are not even distinguishable and error will occur at receiver. Therefore the information capacity is specified by bandwidth-distance product (MHz • km).
- For step index bandwidth distance product is 20 MHz ■ km and for graded index it is 2.5 MHz ■ km.
- The bandwidth decreases with increase in optical cable length. The information carrying capacity can be computed by short light pulse propagating along the fiber.

Group Delay

- Consider a fiber cable carrying optical signal equally with various modes and each mode contains all the spectral components in the wavelength band.
- All the spectral components travel independently and they observe different **time delay** and **group delay** in the direction of propagation.
- The velocity at which the energy in a pulse travels along the fiber is known as **group velocity.** Group velocity is given by,

$$V_g = \frac{\partial w}{\partial \beta}$$

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- Thus different frequency components in a signal will travel at different group velocities and so will arrive at their destination at different times, for digital modulation of carrier, this results in dispersion of pulse, which affects the maximum rate of modulation. Let the difference in propagation times for two side bands is δt

$$\delta\tau = \frac{d\tau}{d\lambda} \times \delta\lambda$$

where,$\delta\tau$ = Wavelength difference between upper and lower sideband (spectral width)

$\frac{d\tau}{d\lambda}$= Dispersion coefficient (D)