1. The differences between ordinary light and LASER light are:
   - Ordinary light is incoherent, with random phase and direction, while LASER light is coherent, with the same phase and direction.
   - Ordinary light has multiple wavelengths and spreads out in all directions, while LASER light has a single wavelength and is highly directional.
   - Ordinary light has low intensity and power, while LASER light has high intensity and power.

2. Three important requirements for lasing action are:
   - Population inversion: more atoms or molecules in the excited state than in the ground state.
   - Optical feedback: a means of reflecting light back and forth through the gain medium to stimulate emission.
   - Pumping mechanism: to provide energy to the gain medium to achieve population inversion.

3. Two conditions needed for confining light within the fibre:
   - The refractive index of the core must be higher than that of the cladding to ensure total internal reflection.
   - The core-cladding interface must be smooth to prevent light leakage.

4. Components of a laser device include a gain medium, pump source, optical resonator (comprised of mirrors), and output coupler. The optical resonator is crucial in a lasing system as it provides the feedback mechanism required for stimulated emission to occur.
5. Four advantages of fibre optics over traditional metal communication lines:
   - Higher bandwidth and data transmission capacity.
   - Lightweight and flexible, allowing for easier installation.
   - Immune to electromagnetic interference.
   - Greater distance coverage without loss of signal quality.

6. Short notes:
   - Population inversion: When more atoms are in an excited state than in the ground state, a necessary condition for lasing action.
   - Metastable states: Excited states that have longer lifetimes, crucial for maintaining population inversion.
   - Coherence length: The distance over which light maintains a constant phase relationship, important for interference effects.

- Stimulated emission: Process where an incoming photon triggers the emission of another photon of the same energy, phase, and direction.

7. The relation between Einstein's A and B coefficients is:

$$A = \frac{8\pi h\nu^3}{c^3}B$$

8. Ruby Laser construction involves a ruby rod as the gain medium, flashlamp for pumping, and mirrors to form the optical resonator. When excited, the ruby rod produces coherent red light due to stimulated emission.
9. a) The He-Ne laser works by using a helium-neon mixture as the gain medium, with an electrical discharge pumping mechanism. The population inversion leads to coherent red light emission at 632.8 nm. b) Advantages of He-Ne laser include high coherence, low divergence, and precise wavelength.
10. An optical fibre is a thin, transparent strand made of glass or plastic that guides light through total internal reflection. It consists of a core (where light travels) surrounded by cladding (to maintain total internal reflection).
11. Total internal reflection occurs when light is completely reflected back into a medium from the interface with another medium, occurring when the angle of incidence is greater than the critical angle given by:

$$\sin c = \frac{n_2}{n_1}$$

12. a) Numerical aperture (NA) and acceptance cone determine the light gathering ability of an optical fibre. NA is given by:

$$NA = \sqrt{n_1^2 - n_2^2}$$

b) Two applications of optical fibres include telecommunications and medical imaging.

15. Step-Index Fiber Parameters In Water Environment

Given:

- **Core refractive index, (n_1 = 1.50)**
- **Cladding refractive index, (n_2 = 1.40)**
- **Surrounding medium (water) refractive index, (n = 1.33)**

Numerical Aperture (NA) Calculation:

The Numerical Aperture (NA) of a step-index fiber is given by:

$$\mathrm{NA} = \sqrt{n_1^2 - n_2^2}$$

Substitute the given values:

$$\mathrm{NA} = \sqrt{1.50^2 - 1.40^2} = \sqrt{2.25 - 1.96} = \sqrt{0.29} \approx 0.5385$$

Acceptance Angle Calculation:

The acceptance angle, (\theta), is related to the Numerical Aperture by:

$$\mathrm{NA} = n \sin(\theta)$$

Substitute the values:

$$0.5385 = 1.33 \sin(\theta)$$

Solving for (\theta):

$$\sin(\theta) = \frac{0.5385}{1.33} \approx 0.4045$$

$$\theta \approx \sin^{-1}(0.4045) \approx 23.62^\circ$$

16. Fiber Loss Calculation

Given:

- **Length of fiber, (L = 1.5 , \text{km})**
- **Power reduction factor, (\text{PRF} = 25% = 0.25)**

The fiber loss, (\text{Loss}), in decibels per kilometer can be calculated using:

$$\mathrm{Loss} = -10 \log_{10}\left(\frac{\mathrm{PRF}}{L}\right)$$

Substitute the given values:

$$\text{Loss} = -10\log_{10}\left(\frac{0.25}{1.5}\right) = -10\log_{10}\left(\frac{1}{6}\right) \approx -10\log_{10}(0.1667) \approx 7.78, \text{dB/km}$$

17. Glass-Clad Fiber Characteristics

Given:

- **Core refractive index, (n_1 = 1.5)**
- **Fractional index difference, (\Delta = 0.0005)**

(A) Cladding Index ((N_2)) Calculation:

The cladding refractive index can be calculated as:

$$n_2 = n_1 \times (1 - \Delta)$$

Substitute the values:

$$n_2 = 1.5 \times (1 - 0.0005) = 1.5 \times 0.9995 = 1.49825$$

(B) Critical Angle Calculation:

The critical angle, (\theta_c), is given by:

$$\sin(\theta_c) = \frac{n_2}{n_1}$$

Substitute the values:

$$\sin(\theta_c) = \frac{1.49825}{1.5} \approx 0.9988333$$

$$\theta_c \approx \sin^{-1}(0.9988333) \approx 85.89^\circ$$

(C) Acceptance Angle Calculation:

The acceptance angle (\theta) is related to the Critical Angle by:

$$\text{NA} = n\sin(\theta) = n_1\sin(\theta)$$

Given (\text{NA} = 0.5385) (from previous calculation), we can calculate the acceptance angle.

(D) Numerical Aperture (NA) Calculation:

The Numerical Aperture (NA) is given by:

$$\text{NA} = \sqrt{n_1^2 - n_2^2}$$

Substitute the values:

$$\text{NA} = \sqrt{1.5^2 - 1.49825^2} = \sqrt{2.25 - 2.24506256} \approx \sqrt{0.00493744} \approx 0.0703$$