**Q 1. Applications** **of Lasers**

Laser is an optical device that generates intense beam of coherent monochromatic light by stimulated emission of radiation.

Laser light is different from an ordinary light. It has various unique properties such as coherence, monochromacity, directionality, and high intensity. Because of these unique properties, lasers are used in various applications.

**The most significant applications of lasers include:**

* Lasers in medicine
* Lasers in communications
* Lasers in industries
* Lasers in science and technology
* Lasers in military

**Lasers in Medicine**

1. Lasers are used for bloodless surgery.
2. Lasers are used to destroy kidney stones.
3. Lasers are used in cancer diagnosis and therapy.
4. Lasers are used for eye lens curvature corrections.
5. Lasers are used in fiber-optic endoscope to detect ulcers in the intestines.
6. The liver and lung diseases could be treated by using lasers.
7. Lasers are used to study the internal structure of microorganisms and cells.
8. Lasers are used to produce chemical reactions.
9. Lasers are used to create plasma.
10. Lasers are used to remove tumors successfully.
11. Lasers are used to remove the caries or decayed portion of the teeth.
12. Lasers are used in cosmetic treatments such as acne treatment, cellulite and hair removal.

**Lasers in Communications**

1. Laser light is used in optical fiber communications to send information over large distances with low loss.
2. Laser light is used in underwater communication networks.
3. Lasers are used in space communication, radars and satellites.

**Lasers in Industries**

1. Lasers are used to cut glass and quartz.
2. Lasers are used in electronic industries for trimming the components of Integrated Circuits (ICs).
3. Lasers are used for heat treatment in the automotive industry.
4. Laser light is used to collect the information about the prefixed prices of various products in shops and business establishments from the bar code printed on the product.
5. Ultraviolet lasers are used in the semiconductor industries for photolithography. Photolithography is the method used for manufacturing printed circuit board (PCB) and microprocessor by using ultraviolet light.
6. Lasers are used to drill aerosol nozzles and control orifices within the required precision.

**Lasers in Science and Technology**

1. A laser helps in studying the Brownian motion of particles.
2. With the help of a helium-neon laser, it was proved that the velocity of light is same in all directions.
3. With the help of a laser, it is possible to count the number of atoms in a substance.
4. Lasers are used in computers to retrieve stored information from a Compact Disc (CD).
5. Lasers are used to store large amount of information or data in CD-ROM.
6. Lasers are used to measure the pollutant gases and other contaminants of the atmosphere.
7. Lasers helps in determining the rate of rotation of the earth accurately.
8. Lasers are used in computer printers.
9. Lasers are used for producing three-dimensional pictures in space without the use of lens.
10. Lasers are used for detecting earthquakes and underwater nuclear blasts.
11. A gallium arsenide diode laser can be used to setup an invisible fence to protect an area.

**Lasers in Military**

1. Laser range finders are used to determine the distance to an object.
2. The ring laser gyroscope is used for sensing and measuring very small angle of rotation of the moving objects.
3. Lasers can be used as a secretive illuminators for reconnaissance during night with high precision.
4. Lasers are used to dispose the energy of a warhead by damaging the missile.
5. Laser light is used in LIDAR’s to accurately measure the distance to an object.

**Q2. Current Applications for Lasers in the Defense Industry**

Although the development of [laser-enhanced aircrafts](https://www.army.mil/article/163029/Laser_weapons_development_by_2023/) like those of a science fiction film are a possibility in the near future, there are many exciting ways that the defense sector is currently taking advantage of laser technology.

Here are just a few laser applications that are presently being used by the military, as reported by [Science Clarified](https://www.scienceclarified.com/scitech/Lasers/Military-Applications-of-Lasers.html) and [Popular Mechanics](https://www.popularmechanics.com/technology/a18671/using-x-rays-to-find-uranium/):

1. **Range Finders** – Utilizing lasers can help the military calculate important details such as the distance of a specific target by measuring how long it takes for a small beam of light to reach the target.
2. **Designating Bombs** – By shining lasers at the target, the bomb is released at the precise location of the target. This type of bomb is better known as a “smart bomb,” in that it has unique sensors that can detect the laser.
3. **Battle Simulation** – Another successful application of lasers in the military is the use of light-laser guns on battlefields. Through this, soldiers are able to practice on the battlefield to get a better sense of the terrain for future use.
4. **Communicating Underwater –** Since submarines often patrol in enemy territory, lasers have been able to replace the use of radio communication underwater, which had a high risk of being picked up by enemy ships. With the development of this special light beam, underwater communication has become a lot safer and easier.
5. **Finding Bombs in Vehicles** – Lasers x-rays are found to be able to detect and uncover trace amounts of many radioactive elements such as uranium and plutonium, even when the materials are being shielded by thick steel.

Up and Coming Laser Solutions: Landmines and Laser Weapons

On top of the applications of lasers in the defense sector listed above, lasers have also been rumored to be soon helping the military in some brand new areas. Some key insights include:

1. Landmines have been used in war for many decades, and have become an effective tool during combat. However, since landmines last underground for so many years, numerous units are often left in areas that no longer are engaged in war.
2. So now, the U.S. military wants to help dispose of unnecessary landmines with the use of lasers to make former war locations safe for those who live there.
3. Additionally, the possibility of [laser guns and weaponry](https://www.defensenews.com/story/defense/innovation/2016/03/15/laser-weapons-directed-energy-lockheed-pewpew/81826876/) being used in the near future is now close to reality, due to developing technology. According to Lockheed Executives, the technology currently exists, but is going through testing and approval for use in real-life situations.

**Q3. LiDAR**, or light detection and ranging, is a popular remote sensing method used for measuring the exact distance of an object on the earth’s surface. Even though it was first used in the 1960s when laser scanners were mounted to aeroplanes, LiDAR didn’t get the popularity it deserved until twenty years later. It was only during the 1980s after the introduction of GPS that it became a popular method for calculating accurate geospatial measurements. Now that its scope has spread across numerous fields, we should know more about LiDAR mapping technology and how it works. What is LiDAR technology and how does it work? Here are a few insights about it that are good to know.

#### ****LiDAR Technology****

According to the American Geoscience Institute, LiDAR uses a pulsed laser to calculate an object’s variable distances from the earth surface. These light pulses — put together with the information collected by the airborne system — generate accurate 3D information about the earth surface and the target object.

There are three primary components of a LiDAR instrument — the scanner, laser and GPS receiver. Other elements that play a vital role in the data collection and analysis are the photodetector and optics. Most government and private organizations use helicopters, drones and airplanes for acquiring LiDAR data.

#### ****Types of LiDAR Systems****

LiDAR systems are divided into two types based on its functionality — Airborne LiDAR & Terrestrial LiDAR.

**Airborne LiDAR**

Airborne LiDAR is installed on a helicopter or drone for collecting data. As soon as it’s activated, Airborne LiDAR emits light towards the ground surface, which returns to the sensor immediately after hitting the object, giving an exact measurement of its distance. Airborne LiDAR is further divided into two types — Topological LiDAR and Bathymetric LiDAR.

**Terrestrial LiDAR**

Unlike Airborne, Terrestrial LiDAR systems are installed on moving vehicles or tripods on the earth surface for collecting accurate data points. These are quite common for observing highways, analysing infrastructure or even collecting point clouds from the inside and outside of buildings. Terrestrial LiDAR systems have two types — Mobile LiDAR and Static LiDAR.

#### ****How Does LiDAR Work?****

LiDAR follows a simple principle — throw laser light at an object on the earth surface and calculate the time it takes to return to the LiDAR source. Given the speed at which the light travels (approximately 186,000 miles per second), the process of measuring the exact distance through LiDAR appears to be incredibly fast. However, it’s very technical. The formula that analysts use to arrive at the precise distance of the object is as follows:

The distance of the object=(Speed of Light x Time of Flight)/ 2

LiDAR can be used to accomplish many **developmental objectives**, some of which are:

#### ****Oceanography****

When the authorities want to know the exact depth of the ocean’s surface to locate any object in the case of a maritime accident or for research purposes, they use LiDAR technology to accomplish their mission. Other than locating objects, LiDAR is also used for calculating phytoplankton fluorescence and biomass in the ocean surface, which otherwise is very challenging.

#### ****Digital Elevation or Terrain Model****

Terrain elevations play a crucial role during the construction of roads, large buildings and bridges. LiDAR technology has x, y and z coordinates, which makes it incredibly easy to produce the 3D representation of elevations to ensure that concerned parties can draw necessary conclusions more easily.

#### ****Agriculture & Archaeology****

Typical applications of LiDAR technology in the agriculture sector include analysis of yield rates, crop scouting and seed dispersions. Besides this, it is also used for campaign planning, mapping under the forest canopy, and more.

**Q 4. Optical communication** is any type of communication in which light is used to carry the signal to the remote end, instead of electrical current. Optical communication relies on optical fibers to carry signals to their destinations. A modulator/demodulator, a transmitter/receiver, a light signal and a transparent channel are the building blocks of the optical communications system.

Because of its numerous advantages over electrical transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world.

Since the development of low-loss optical fiber cables in the 1970s, optical communications became one of the most popular methods of communication. Optical communication systems consist of the following components:

1. **Transmitter:** Converts and transmits an electronic signal into a light signal. The most commonly used transmitters are semiconductor devices, such as light-emitting diodes (LEDs) and laser diodes.
2. **Receivers:** Typically consist of a photo-detector, which converts light into electricity using the photoelectric effect. The photo detector is typically a semiconductor-based photodiode.
3. **Optical Fiber**: Consists of a core, cladding and a buffer through which the cladding guides the light along the core by using total internal reflection.

The main benefits of optical communication include high bandwidth, exceptionally low loss, great transmission range and no electromagnetic interference. The cons of optic communication include the high cost of cable, transmitter/receiver and other support equipment, and the skill and expertise required during cable installation and interconnection.

**Q5. A barcode reader (or barcode scanner)** is an optical scanner that can read printed barcodes, decode the data contained in the barcode and send the data to a computer. Like a flatbed scanner, it consists of a light source, a lens and a light sensor translating for optical impulses into electrical signals. Additionally, nearly all barcode readers contain decoder circuitry that can analyze the barcode's image data provided by the sensor and sending the barcode's content to the scanner's output port.

**Q6. The Laser Interferometer Gravitational-Wave Observatory (LIGO)** is an ambitious physics experiment designed to measure gravitational wavesreaching our planet from deep space. Gravitational waves are elusive ripples in the fabric of the universe. [First predicted to exist in 1915](https://www.ligo.caltech.edu/video/ligo01032005v), they escaped direct detection for a century. [LIGO](https://www.kavlifoundation.org/how-ligo-works) was designed to register the astonishingly tiny effects of passing gravitational waves here on Earth using a precise arrangement of mirrors, lasers, monitoring equipment and other advanced technologies. In February 2016, LIGO researchers announced the long-awaited, first-ever direct sensing of gravitational waves.