# RAJIV GANDHI COLLEGE OF ENGINEERING AND TECHNOLOGY

# DEPARTMENT OF BIO-MEDICAL ENGINEERING

## UNIVERSITY EXAMINATION QUESTION PAPER KEY, JANUARY 2023

**SUBJECT: MEDICAL OPTICS** **YEAR/SEM:IV/VII**

**1. Give the features of optothermal interaction**

optoacoustic spectroscopies

tomography

microscopy

**2. Define speckle. (INT-2)**

When laser light illuminates a diffuse object, it produces a random interference effect known as a speckle pattern. If there is movement in the object, the speckles fluctuate in intensity. These fluctuations can provide information about the movement.

**3. Differentiate scattering coefficient and absorption coefficient.(INT-2)**

The scattering coefficient is a measure of the ability of particles to scatter photons out of a beam of light, while the absorption coefficient is a measure of how many photons are absorbed. Each parameter is expressed as a number proportional to the amount of photons scattered or absorbed per distance.

The absorption coefficient $\alpha(\lambda)$ describes the intensity attenuation of the light passing through a material. It can be understood as the sum of the absorption cross-sections per unit volume of a material for an optical process

**4. Mention the properties of laser.**

- **Monochromatic:**

  It means that it consist of one color or wavelength

- **Divergence and directionality:**

  It means that the beam is well collimated and travels long distance with very little spread.

- **Coherence:**

  It means that all the individual waves of light are moving preciesly together through time and space.

- **Brightness:**

The radiance of laser is an important factor. It is defined as the power emitted per unit surface area per unit solid angle.

**5. Write the mechanism of laser tissue welding.**

The function of lasers in welding is to bring about efficient delivery of heat to the tissues in the junction. The main molecules that absorb heat are water, hemoglobin, and melanin. Water has strong absorption in the NIR region. This makes the use of solid-state and $CO_2$ lasers ideal for water based heating

**6. Tabulate various types of lasers with its application.**

Gas Lasers

Solid-State Lasers

Fiber Lasers

Liquid Lasers (Dye Lasers)

Semiconductor Lasers (Laser Diodes)

**7. What are wave fronts?**

A wavefront is an imaginary surface representing corresponding points of a wave that vibrate in unison. A wavefront is the set of all locations in a medium where the wave is at the same phase. This could be where all the crests are, where all the troughs are, or any phase in between.

**8. List down the properties of hologram.**

The images are true three-dimensional images, showing depth and parallax and continually changing in aspect with the viewing angle.

Any part of the hologram contains the whole image!

The images are scalable. They can be made with one wavelength and viewed with another, with the possibility of magnification

**9. What is near field imaging?(MODEL)**

Near-field imaging occurs when a sub-micron optical probe is positioned a very short distance from the sample and light is transmitted through a small aperture at the tip of this probe.

**10. Mention the application of elastrography.**

Elastography uses low frequency vibrations during an ultrasound or MRI to measure the stiffness (or elasticity) of organs inside the body.

It is particularly useful for detecting the presence and severity of liver disease.

**PART-B (5X11=55 Marks)**

**11. Describe in detail about the three levels of absorption process.**

Absorption is a process involving the extraction of energy from light by a molecular species. In biomedical Photonics, absorption processes are important in diagnostic and therapeutic applications:

+Diagnostic applications: Transitions between two energy levels of a molecule that are well defined At specific wavelengths could serve as a spectral fingerprint of the molecule for diagnostic purposes.

+Therapeutic applications: Absorption of energy is the primary mechanism that allows light from a laser to produce physical effects on tissue for treatment purposes.

Absorption processes involve an important concept in quantum theory, the energy level, which is a quantum state of an atom or molecule. The shift of a species (ie., a molecule of an atom) from one energy level to another is called a transition. A transition of a species from a lower to a higher energy level involves excitation to an excited state and requires absorption of an amount of photon energy, Av, equal to the difference in energy, AE, between the two levels:

A drop from a higher energy level to a lower level is called a decay and is accompanied by a release of energy equal to the difference in energy between the two levels. This release of energy may occur without radiation (by heating the surrounding medium) or may give rise to emission of a photon (eg.. luminescence).

In the quantum picture, photons are absorbed by atoms and molecules in specific transitions, and the photons' energy is used to increase their internal energy states. The regions of the spectrum where this occurs are known as absorption bands; these bands are specific to particular molecular/atomic species. In general, there are three basic types af absorption processes: (1) electronic, (2) vibrational, and (3) rotational.

Bectronic transitions occur in both atoms and molecules, whereas vibrational and rotational transitions occur only in molecules.

**Absorption between Electronic Levels**

At equilibrium, a group of molecules has a thermal distribution in the lowest vibrational and rotational levels of the ground state, S,. When a molecule absorbs excitation energy, it is elevated from S, to some vibrational level of one of the excited singlet states, $,, in the manifold S,...S,. The intensity of the absorption (i.e., fraction of ground-state molecules promoted to the electronic excited state) depends on the intensity of the excitation radiation (i.e., number of photons) and the probability of the transition with photons of the particular energy being used. A term often used to characterize the intensity of an absorption (or an induced emission) band is the oscillator strength, f, which may be defined from the integrated absorption spectrum by the relationship

Oscillator strengths of unity or near unity correspond to strongly allowed transitions, whereas lower values of f are indicative of the smaller transition dipole matrix elements of forbidden transitions. Depending on the types of species, electronic transitions have energies corresponding to photons from the UV through the IR regions of the spectrum.

**Absorption Involving Vibrational Levels**

Vibrational levels characterize the different states of vibration of the atoms in a molecule. The vibrations in various degrees of freedom are quantized, giving rise to a series of vibrational levels for each vibrational pattern of a molecule. A vibrational transition occurs when a molecule shifts from one vibrational state to another. Typically, vibrational transitions correspond to the energies of photons from the IR.

**Absorption Involving Rotational Levels**

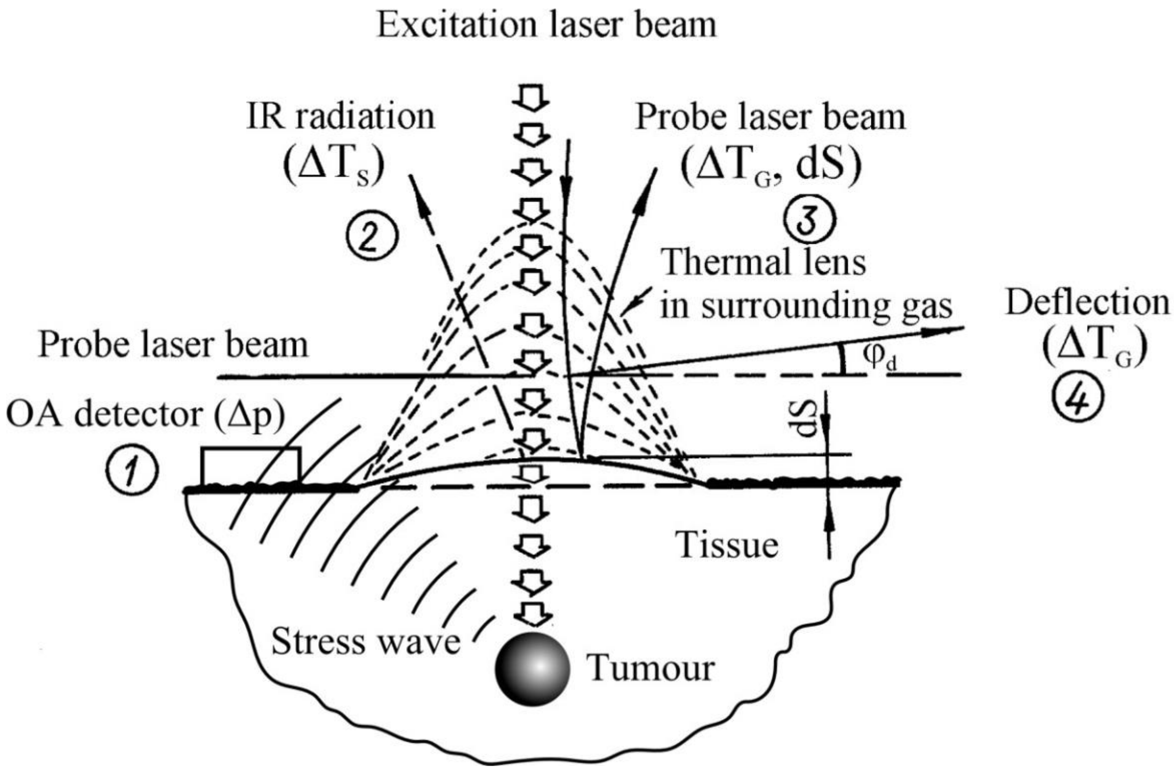
Rotational levels represent the different states of rotation of a molecule. These quantized energy levels correspond to photon energies from the far IR to submillimeter wavelengths.

The electronic energy levels of molecules are associated with molecular orbitals that describe the distribution of the electrons (ie., electron clouds) in the molecule. When a molecule undergoes an electronic transition, an electron is transferred from one molecular orbital to another. However, there are cases where the excitation is considered to be localized to a particular bond or groups of atoms. Several types of molecular orbitals are involved in biological compounds: x bonding orbitals, x* non-bonding orbitals, and # nonbonding (lone-pair) orbitals. The x* nonbonding orbital is less stable and has a higher energy than the 1 bonding orbital. An electronic transition involving the transfer of an electron from an orbital to a x* orbital is called a wx* transition. Alternatively, the transfer of an electron from an 1: orbital to a x" orbital is called an n1* transition. In transition metal complexes (e.g., metal porphyrins), the electronic energy levels may also be described by molecular orbitals formed between the metal and ligands. The term chromophore refers to the part of the molecule that gives rise to the electronic transition of interest.

The probability of transition between different states or energy levels is governed by complex quantum Mechanical rules that depend on the chemical structure, size, and symmetry of the molecules. Some Transitions are said to be "allowed," which means that they are very likely to occur, thus giving rise to Very strong absorption bands. Others are "forbidden" transitions, which are very unlikely to occur, producing very weak absorption bands.

**12. Enumerate tissue optical properties that can be measured.(MODEL)**

The time dependent heat generation in a tissue at interaction with optical radiation is known as optothermal (OT) effect. This interaction also induces a number of thermoelastic effects in a tissue in particular causes generation of acoustic waves. Detection of acoustic waves is a basis for optoacoustic (or photoacoustic) method. The informative features of this method allow one to estimate tissue thermal, optical and acoustical properties which depend on tissue structure peculiarities.




Two main modes can be used for excitation of tissue thermal response:

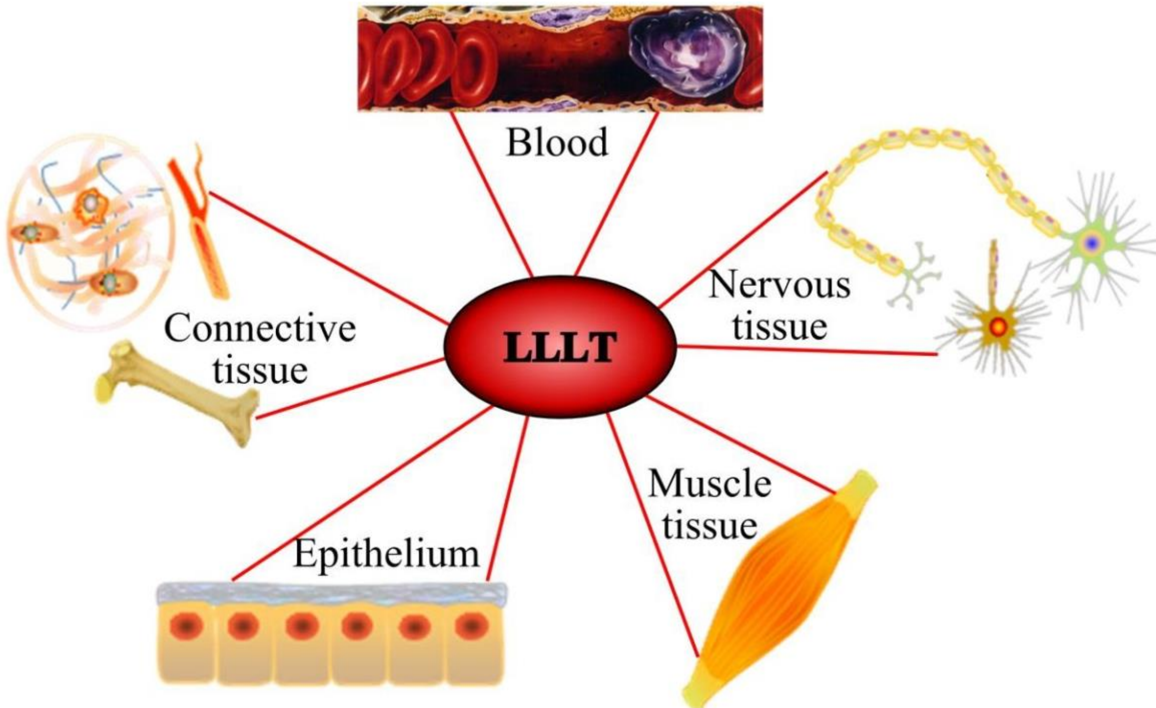
1) a pulse of light excites the sample and the signal is detected in the time domain with a fast by acoustic transducer attached to a wide band amplifier (signal averaging and gating techniques are used to increase the signal-to-noise ratio) 2) an intensity modulated light source is used and the phase sensitive signal detection for the selected modulation frequency is provided.

In every case the thermal waves generated by the heat release result in several effects which have given rise to various techniques:

1. Optoacoustics (OA) or photoacoustics (PA)

2. Optothermal radiometry (OTR) or photothermal radiometry (PTR) Photorefractive techniques, and etc.

When a laser beam falls down to the sample surface and the wavelength is tuned to an absorption line of the tissue component of interest the optical energy is absorbed by the target component and the most of the energy transforms to heat.




The time dependent heating leads to all of above mentioned thermal and thermoelastic effects. In OA or PA techniques, a microphone or piezoelectric transducer which are in acoustic contact with the sample are used as detectors to measure the amplitude or phase of the resultant acoustic wave. In OTR technique, distant IR detectors and array cameras are employed for the sample surface temperature estimation and its imaging.

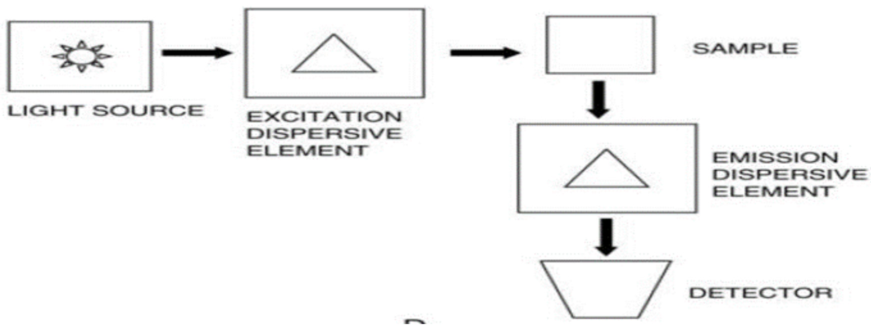
Two widely spread therapeutic applications:

- ❖ Photodynamic therapy (PDT)
- ❖ Low level light therapy (LLLT)

**13. Explain the instrumentation of emission measurement. (INT-1)**

The excitation light source is usually a laser or high-intensity xenon arc lamp. The collimated output of the light source is focused on the entrance slit of an excitation monochromator whose output is directed to the sample. When a laser is used as the excitation source, the excitation monochromator is not required. The emission from the sample is collected through appropriate optics and focused onto the entrance slit of an emission monochromator. The excitation beam and the emission beam are usually focused at right angles for minimum interference from scattered light.

There are three basic classes of spectrophotometers: filter instruments, monochromator instruments, and multichannel devices. The first type of device uses optical filters, whereas the latter two systems use prisms or gratings as dispersive elements. The three major features to consider are the intensity of the excitation light source, the resolution and throughput of the monochromators, and the sensitivity of the detector.




Emission Measurement

**14. Discuss in detail on high pressure arc lamp.**

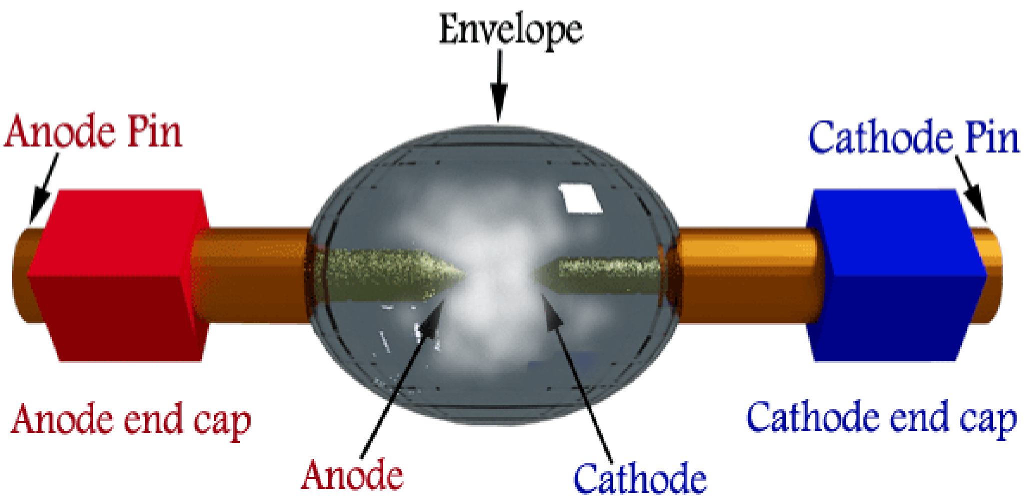
**Xenon arc lamp:**

A xenon arc lamp is a special type of gas discharge lamp. Xenon arc lamps produce light by passing electricity through ionized xenon gas at high pressure. It produces a bright white light that closely mimics natural sunlight, which extends its applications into the film, and daylight simulation industries.

Construction:

Thoriated tungsten is the tungsten added with 1 to 2% thorium to give extra strength to the arc by enhancing the electron emission capability of tungsten. Fused silica is also called quartz. It is non crystalline transparent silicon dioxide glass which provides extra strength and almost zero thermal expansion. It can withstand high pressure at high temperatures. The envelope or bulb is filled with xenon gas in very high pressure. The pressure inside the bulb is about 30 bars. Here, when voltage is applied across the electrodes, the gas discharge phenomenon starts in the xenon gas in the gap between electrodes. There are always present some free electrons in the gas. Due to the applied electric field across the electrodes, the free electrons get accelerated and collide with xenon atoms. Due to these collisions electrons from the

outer orbit of the xenon atoms get detached from their position and come to the higher energy level. Atoms with electrons of higher energy levels are called excited atoms.




When in the excited atoms, the electrons return from its higher energy level to its previous energy state, the extra energy is released as a photon. The wavelength of energy emitted through photons is within visual range. The color of the light of xenon arc light is like daylight. Due to the electrostatic attraction of anode or positive electrodes, the free electrons originated due to the ionization process ultimately comes to the anode and returns to the source.

**Working:**

Here, when voltage is applied across the electrodes, the gas discharge phenomenon starts in the xenon gas in the gap between electrodes. There are always present some free electrons in the gas. Due to the applied electric field across the electrodes, the free electrons get accelerated and collide with xenon atoms. Due to these collisions electrons from the outer orbit of the xenon atoms get detached from their position and come to the higher energy level.

Due to the electrostatic attraction of anode or positive electrodes, the free electrons originated due to the ionization process ultimately comes to the anode and returns to the source.

Due to the attraction of the cathode, the positive ions ultimately collide with the cathodes front surface and generate positive metal ions, neutral xenon atoms, and free electrons.

These electrons are called secondary emitted electrons. These electrons help to continue the gas discharging process. As the cathode is not additionally heated for electron emission, the cathode of xenon arc lamp or xenon lamp is known as a cold cathode.

Xenon arc lamps are used for:

- Specialized uses in industry and research to simulate sunlight
- Searchlights
- Movie projectors in theaters

**15. Write the application of laser in visual laser ablation of the prostate (VLAP).**

Laser ablation means removing some material from a solid surface using intense laser light, usually in the form of a laser beam. This term is often not regarded as a laser application as such, but rather as a process which is utilized in the context of specific applications in subtractive laser material processing (laser machining), such as laser engraving, cutting or drilling.

**Applications of Laser Ablation**

**Laser ablation processes are utilized in many areas of laser material processing:**

In laser machining processes like laser cutting, drilling and laser milling, the removal of some amount of material is required.

The same holds for laser engraving for purposes of laser marking or others. Here, one often needs to remove material up to a well-defined depth. The achieved uniformity and a low roughness of the resulting lowered surface can be important. Usually, the ablation is done with a sequence of many laser pulses, each one slightly moved against the position of the previous one. Such processes are possible with a wide range of materials, such as metals, ceramics, glasses and polymers.

Machine parts are processed to get microtextured surfaces, e.g. in order to reduce friction of lubricated parts – for example on cylinders and pistons of combustion engines.

Some kinds of laser surface modification also involve ablation, normally on a microscopic scale.

Laser cleaning means the removal of some unwanted type of material, which often absorbs the laser radiation better than the underlying substrate. That selectivity is in practice often very helpful for completely removing all unwanted material while preserving the substrate material.

Thin-film photovoltaic panels need to be insulated at their boundaries, i.e., a metallic layer needs to be ablated.

Pulsed laser deposition utilizes laser ablation of a material in order to deposit it elsewhere.

An exotic application would be laser propulsion, utilizing the recoil of ablated material [6]. For recoil velocities well above the exhaust gas velocities of rockets, laser propulsion may be more efficient in terms of required mass of propellant, while requiring more energy (e.g. from a nuclear reactor).

There are also applications outside the area of material processing, e.g. laser-induced breakdown spectroscopy (LIBS). Here, one spectrally analyzes the radiation of the generated plasma plume.

**Non-technical applications of laser ablation are mainly in the area of medicine:**

Laser surgery allows one to very accurately remove fine structures (e.g. parts of malignant tumors) without significantly affecting their neighborhood; the processing speed, however, may be quite low.

Laser ablation can also be used in dentistry for curing caries; when using lasers with suitably long wavelength, one can obtain selective removal of caries-affected tissue while preserving the unaffected parts of a tooth.

## 16. Discuss the application of laser in dermatology (MODEL)

### Lasers in Dermatology

Wound healing Lasers operating at energies (low power lasers) that do not produce any thermal effect are able to produce photobioactivation. They are used for the treatment of leg ulcers and other chronic wounds**.**

### Use of Laser in dermatology

**Vascular lesions** Flashlamp-pumped pulsed dye laser is used in the treatment of port wine stains. It is also used in superficial capillary haemangiomas. Replacing the Argon Laser, the Pulsed Dye Laser became the preferred laser for the treatment of vascular lesions. Including spider veins, strawberry birthmarks and port wine stains and a whole range of cutaneous vascular anomalies.

**Removing of skin lesions** For Removal of benign skin lesion, such as moles. warts, keratoses CO2 lasers are the preferred. They are used also for shaving, cutting, dermabrading and resurfacing sears.

**Pigmented lesions** Low-power continuous wave lasers of appropriate wavelength can be used successfully to treat melanin-containing lesions . The Q-Switched Nd: YAG is effective for treatment of pigmented lesions, including removal of black tattoos. Implanted dermal pigment may be treated with the carbon dioxide laser .The Ruby laser (emits red light is used in the treatment of tattoos and some other pigmented lesions including freckles. liver spots. Nevus of Ota, cafe-au-lait spots (in Q-Switched mode).

**Hair removal** The Alexandrite Laser removes the hair in millisecond- pulsed mode). Nd:YAG laser light is also effective for long-term hair removal.

**Resurfacing** Acne scars and extensive areas of skin damaged by photo ageing have.

Good results with the use of carbon dioxide laser.

**17. Elaborate on fiber based optical coherence tomography.(MODEL)**

## Principle of OCT

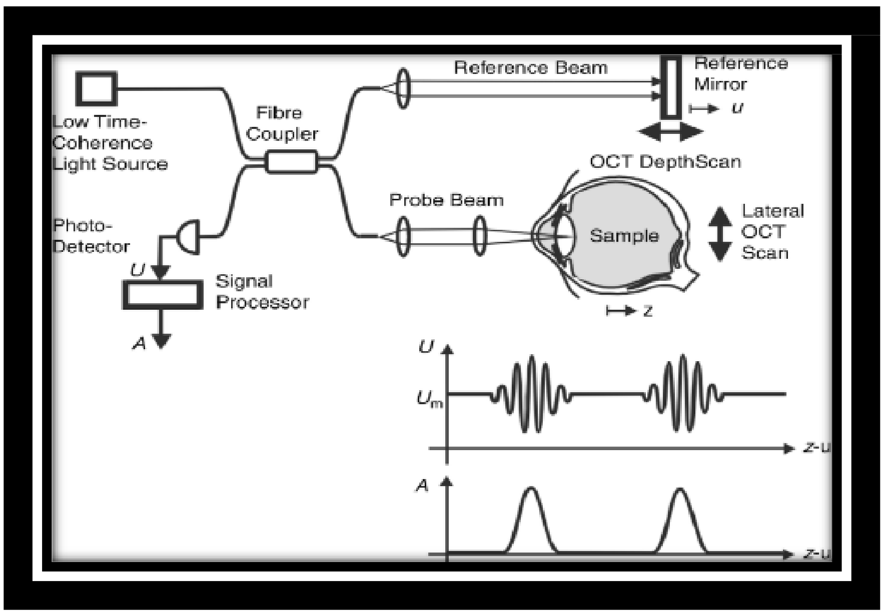
OCT is often compared to medical ultrasound because of the similar working principles. Both medical imaging techniques direct waves to the tissue under examination, where the waves echo off the tissue structure. The back reflected waves are analyzed and their delay is measured to reveal the depth in which the reflection occurred. OCT uses light in the near- infrared, which travels much faster than ultrasound. The delays of the back-reflected waves cannot be measured directly, so a reference measurement is used. Through the use of an interferometer, part of the light is directed to the sample and another portion is sent to a reference arm with a well-known length.

The idea of low-coherence interferometry is the underlying principle for all OCT implementations. Temporal coherence is a property of a light source and characterizes the temporal continuity of a wave train sent out by the source and measured at a given point in space. Wave trains emerging from a light source of low temporal coherence maintain a fixed phase relation only over a very limited time interval corresponding to a confined travel range, the coherence length or coherence gate. A light source with a broad spectral bandwidth is composed of a range of wavelengths. Such a broadband source has low coherence, while monochromatic laser light has a narrow spectral line and features a coherence length of at least several meters. An interferometer splits light, coming from a source, into two separate paths and combines the light coming back from the two paths at the interferometer output. There, under certain conditions, interference can be observed: coherent waves superimpose and their electromagnetic field amplitudes add constructively (i.e. they reinforce each other) or destructively (i.e. they cancel out each other) or meet any condition in between. The associated light intensity can be measured as an electrical signal using a photo detector.

**Technical realizations of OCT**

In the first implementation of OCT , the reference length was modulated for each depth scan and the record of the intensity of the combined light at the sensor gave the reflectance profile of the sample. This variant is called time-domain OCT (TD-OCT) .

**Working principle of TD-OCT :** light from the light source is split into the reference beam and the central beam. Back reflected light from both arms is combined again and recorded by the detector. To record one depth profile of the sample (A-scan) the reference arm needs to be scanned. This has to be repeated for each lateral scan position.




As depicted, the light of a low-coherence source is guided to the interferometer, which in this example is a fiber-based implementation. In a system using bulk optics the fiber coupler is replaced by a beam splitter. The input beam is split into the sample beam and into the reference beam travelling to a mirror on a translational stage. The back-reflected light from each arm is combined and only interferes if the optical path lengths match and therefore the time travelled by the light is nearly equal in both arms. Modulations in intensity, also called interference fringe bursts, are detected by the photodiode. The amount of back-reflection or back-scattering from the sample is derived directly by the envelope of this signal.

For each sample point, the reference mirror is scanned in depth (*z*) direction and the light intensity is recorded on the photo detector. Thereby a complete depth profile of the sample reflectivity at the beam position is generated, which—in analogy to ultrasound imaging—is called A-scan (amplitude scan).

To create a cross-sectional image (or B-Scan), the sample beam is scanned laterally across the sample. This abbreviation originated in ultrasound imaging, where B-Scan means brightness scan.

Fourier domain OCT (FD-OCT , also frequency domain OCT) is the second generation of OCT technology and provides a more efficient implementation of the principle of low- coherence interferometry.

Optical setup of spectrometer based OCT (SD-OCT) in the upper left inset and swept source OCT (SS-OCT) in the upper right inset. While SD-OCT uses a spectrometer for wavelength separation, SS-OCT features a light source which sweeps the wavelength in time. Both implementations record an interference spectrum which carries the depth in formation of the sample. FFT is used to transform the interference signal into the A-scan.

**18. Write the working principle with advantages of Elastrography.**

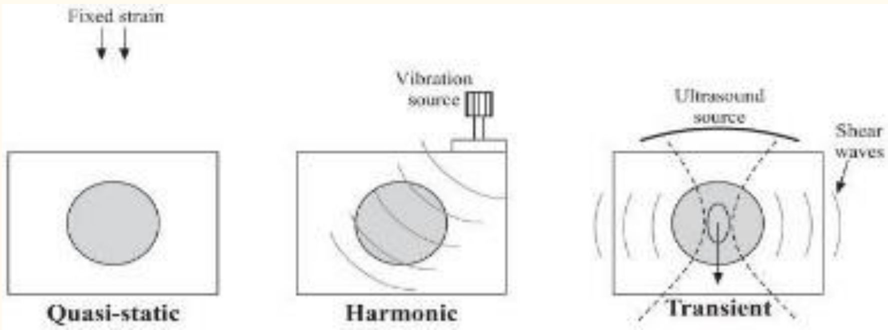
(1) Perturb the tissue using a quasi-static, harmonic, or transient mechanical source;

(2) Measure the resulting mechanical response (displacement, strain or amplitude and phase of vibration); and

(3) Infer the biomechanical properties of the underlying tissue by applying either a simplified or continuum mechanical model to the measured mechanical response In this chapter, we will describe

(a) The general principles of quasi-static, harmonic, and transient elastography the most popular approaches to elastography and

(b) The physics of elastography—the underlying equations of motion that governs the motion in each approach. We also provide examples of clinical applications of each approach.




**Applications**

- Elastography is used for the investigation of many disease conditions in many organs. It can be used for additional diagnostic information compared to a mere anatomical image, and it can be used to guide biopsies or, increasingly, replace them entirely. Biopsies are invasive and painful, presenting a risk of hemorrhage or infection, whereas elastography is completely noninvasive.
- Naturally, elastography sees use for organs and diseases where manual palpation was already widespread. Elastography is used for detection and diagnosis of breast, thyroid, and prostate cancers. Certain types of elastography are also suitable for musculoskeletal imaging, and they can determine the mechanical properties and state of muscles and tendons.
- Preliminary reports on elastography used on transplanted kidneys to evaluate cortical fibrosis have been published showing promising results.

**19. Discuss in detail about Photodynamic Therapy in cancer treatment. (MODEL)**

❖ **Introduction**

- Photodynamic therapy (PDT) is a modern and non-invasive form of therapy, used in the treatment of non-oncological diseases as well as cancers of various types and locations.
- Good therapeutic results and the possibility of the parallel application of PDT with other therapeutic protocols make it more commonly used in many fields of medicine. PDT has been successfully used in dermatology, oncology, gynecology and urology.
- Photodynamic therapy is based on the local or systemic application of a photosensitive compound - the photosensitizer, which is intensely accumulated in pathological tissues.
- The photosensitizer molecules absorb light of the appropriate wavelength, initiating the activation processes leading to the selective destruction of the inappropriate cells.

- Photodynamic therapy is well tolerated by patients because of its selective action. Photodynamic protocols are painless, and the simplicity of their application allows for outpatient use.
- Photodynamic therapy is also used in the treatment of chronic inflammation and is an interesting alternative in the treatment of drug-resistant bacterial infections. The focus of this review is the anticancer application of PDT, its advantages and possible modification to potentiate its effect.
- Numerous studies indicating the use of photosensitizers in oncology have been carried out over last several decades.
- Despite the success of PDT, new compounds and innovative methods are still being researched and required to improve the effective use of photodynamic therapy in clinical oncology. Previous studies have led to a significant extension of the possible applications and combinations of photodynamic therapy against cancer cells.

- In addition to the traditional drug applications, the use of electroporation and nano carriers is considered to increase the local concentration of the photosensitizer, which results in better efficiency of applied therapy.

- **PDT mechanism**
  - Molecular mechanism of photodynamic therapy is based on the three non-toxic components, which produce the desired effects within pathological tissues only by mutual interactions between: the photosensitizer (PS); Light with the appropriate wavelength; oxygen dissolved in the cells.
  - There are two main mechanisms of the photodynamic reaction. Both are closely dependent on oxygen molecules inside cells. The first stage of both mechanisms is similar.
  - A photosensitizer, after entering the cell, is irradiated with a light wavelength coinciding with the PS absorption spectrum and is converted from the singlet basic energy state S° into the excited singlet state S1 because of the photon absorption.
  - Part of the energy is radiated in the form of a quantum of fluorescence, and the remaining energy directs a photosensitizer molecule to the excited triplet state T1 - the proper, therapeutic form of the compound.

- **Type I of mechanism of photodynamic reaction**
  - In the excited triplet state T1, the photosensitizer can transfer energy to the biomolecules from its surroundings. Between the photosensitizer in the T1 state and the cancerous tissue (substrate), a hydrogen or electron is transferred, which leads to the formation of free radicals and anion radicals of the photosensitizer and the substrate.
  - Electrons interreact with oxygen molecules, which remain in their basic energetic state. This process leads to the production of reactive oxygen species (ROS) - initially in the form of superoxide anion radical ($O_2^{\bullet-}$), which creates further generation of ROS inside the cells.
  - The initiated cascade of reactions leads to the oxidative stress resulting in the destruction of cancer cells.

- **Type II of mechanism of photodynamic reaction**
  - As a result of the photosensitizer's transition into the excited triplet state, energy is transferred directly to the oxygen molecule in the basic energetic state (the basic triplet state). Direct energy transfer between molecules (PS → O2) is possible because they have the same spins.
  - In this way excited oxygen particles - so-called singlet oxygen - are generated, which are characterized by extremely strong oxidizing properties. Most organic compounds are in the basic singlet state.
  - However, oxygen molecules are characterized by their triplet state (as the basis) and excitation into the singlet. Owing to this fact, excited photosensitizer particles do not damage organic cell structures and react only with oxygen molecules dissolved in the cytoplasm.
  - It is assumed that mechanism of type II is the most important process conditioning the efficiency of PDT.
  - Nevertheless, the ratio of the contribution of both mechanisms depends on many factors, including: oxygen concentration, tissue dielectric constant and pH and photosensitizer's structure. As the oxygen runs out, the first type of mechanism begins to prevail.

- Highly reactive oxygen species cause the photodamage of proteins, fats and other molecules in the photosensitized area. This leads to the direct death of tumor cells in the process of apoptosis and / or necrosis.
- The mutual contribution of different types of cell death depends on the intracellular location of photosensitizer. The damage of mitochondria can lead to apoptosis, cell membrane destructions and loss of integrity can induce necrosis, and damage of lysosomes or endoplasmic reticulum can provoke autophagy.

❖ **PDT selectivity**

- The described photocytotoxic reactions occur only within the pathological tissues, in the area of photosensitizer distribution, enabling selective destruction.
- Photosensitizers accumulate in significantly higher concentrations in cancer cells than in regular cells. The reason of such bio distribution may be the tendency of photosensitizers to combine preferentially with low density lipoproteins (LDL).
- The role of LDL is to supply tissues with the necessary cholesterol to create membranes during cell division. Vehemently dividing cancer cells show an increased uptake of LDL lipoproteins, which act as a "transporter" of the photosensitizer to the cancerous tissues.
- In addition, tissues with an increased mitotic activity reveal excessive expression of LDL lipoprotein receptors on the cell surface.
- The affinity of photosensitizers for serum lipoproteins, in particular for LDL, plays an important role in the delivery of these drugs to the tumor tissue. It is known now that PDT leads to a systemic anti-cancer response.
- Photodynamic therapy affects the vascular system of the tumor and stimulates the immune system. The process of destruction of an inappropriate tissue is complemented by the activation of coagulation processes (occlusion of tumor vessels) and local accumulation of inflammatory cells.
- Cancer cells that have escaped death by the direct photocytotoxic effects of PDT may still be destroyed via the indirect influence of PDT on tumor blood vessels. Reactive oxygen species damage of vascular endothelial cells activates clotting processes,

aggregate platelets and block vessels by forming thrombi. As a result of vascular occlusion, persistent hypoxia of tumor tissue leads to the cell death.

- Furthermore, the efficiency of the PDT-method is associated with systemic anti-cancer immune response of the body. PDT destroys the structure of the tumor and thus stimulates direct interaction between immune cells and cancer cells.
- Direct destruction in tumor tissue leads to the development of a strong inflammatory reaction and neoplasm infiltration by leukocytes.
- Membrane photo damages lead to the activation of phospholipases, and then cyclooxygenases, causing massive release of inflammatory mediators - lipid hydrolysis products and arachidonic acid metabolites. Photo-injuries of the blood vessel walls attract neutrophils and macrophages.
- Neutrophil degranulation as well as the release of lysosomal enzymes and chemotactic factors additionally contribute to the destruction of tumor tissue, exacerbating the destruction process initiated by the earlier irradiation.

## Importance of Photodynamic Therapy

- Photodynamic therapy is an unconventional treatment modality for neoplastic conditions and a promising treatment for recurrent cancers, depending on photochemical reactions and subsequent damage, and leading to cancer cell death.
- **Advantages of PDT**
  - It has no long-term side effects when used properly.
  - It’s less invasive than surgery.
  - It usually takes only a short time and is most often done as an outpatient procedure.
  - It can be targeted very precisely.
  - Unlike radiation, PDT can be repeated many times at the same site if needed.
  - There’s usually little or no scarring after the site heals.
  - It often costs less than other cancer treatments.

**20. Enumerate the application of optical holography in medical field.**

**View of human skeletons**

With the help of holography, doctors can see accurate human skeletons, organs, muscle, veins and vessels it helps the surgeon for proper training and planning of the operation

Precisely shows complete skeleton with arteries plus nervous system and other aspects of the body

Make effective representation of brain image and its intricate parts

Helpful to improve the quality of treatment efficiently

**Identification of abnormal growth**

This technology enables to identify the abnormal growth of tissue, organs and even external body parts

Researcher use holography to detect diseases and proper monitoring of health conditions like infections and hormone imbalance

Helpful to researcher and doctors to eliminate the requirement of the physical testing procedure

Useful technology for proper representation of the abnormal 3D structure and other unwanted growth/fats

Used for the disease forecasting and identify advancement for the treatment procedure

**Detect serious abnormalities**

Used to detect a severe issue/abnormalities in tissues and organs in the human body

The advancement of this technology is for various types of cells and Deoxyribonucleic Acid (DNA)

Provide multidimensional information by performing simultaneous imaging about abnormalities

Useful to carry out proper detection of disease, biomedical research & analysis and other related applications

**Inside map of the patient body**

This technology allows the surgeon to see inside the patient body and facilitate the study of tissue structure and other damages/growth

Heart surgeon use hologram to see the children heart which can be helpful during the operations

Help Doctors carry dedicated procedures by employing a proper inside map with precision

Holography images are beneficial during surgery and are useful in comparing it with the previously captured image

Used to detect the blood loss during the surgery which can provide proper information to the surgeon

Inside fracture in bone and tissue can be analysed before the actual operation

**Outside mapping of patient body**

Doctors can see the external parts and other related details of the patient body and facilitate disease detection and remote treatment

This technology is suitable to deliver effective teaching for imparting better medical education

Useful for detection of abnormality in body parts

Can eliminate some necessary physical testing

**Presentation and simulation**

In medical education, this technology is suitable to deliver an effective presentation to students

It allows for a virtual lecture in real-time with the audience

Provide live simulation for better learning of the procedure

Proper presentation of the cardiovascular system and detect any heart defect at an early stage

Projected 3D holography digital image to precisely analyse the function and blood flow in the cardiovascular system

**Emergency care**

Provide better guidance during an emergency

Helpful for proper treatment during accident situation with the help of previously-stored holography images

Bring new dimensions in modern communication system during emergency care

By using this technology, medical professionals can treat their patient remotely and in isolated areas

In a rural area, it improves access to the specialised consultant, and a patient may not have to visit the doctor physically at a far off place