WINTER – 2019 EXAMINATION

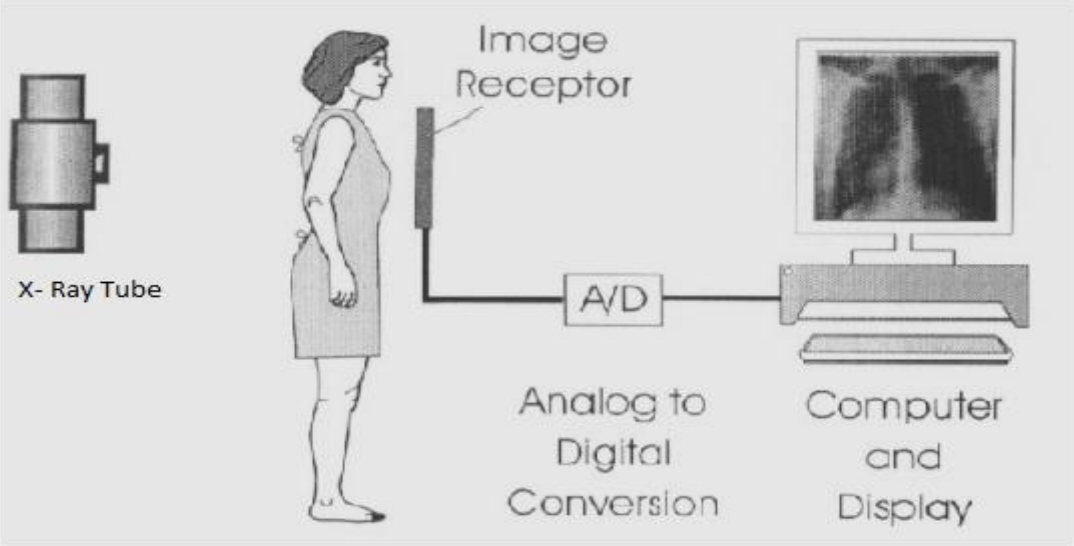
Subject Name: Medical Imaging Equipment **Model Answer** **Subject Code: 22547**

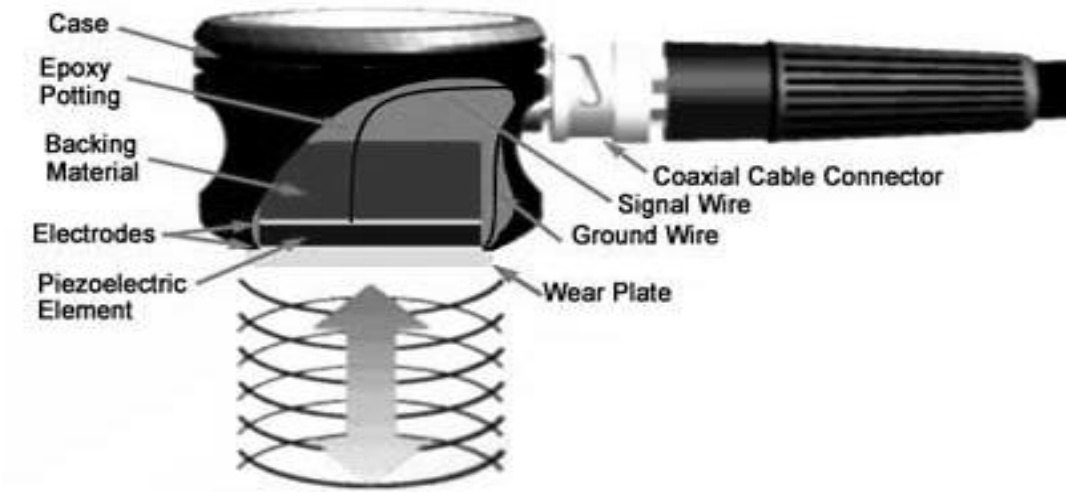
Important Instructions to examiners:

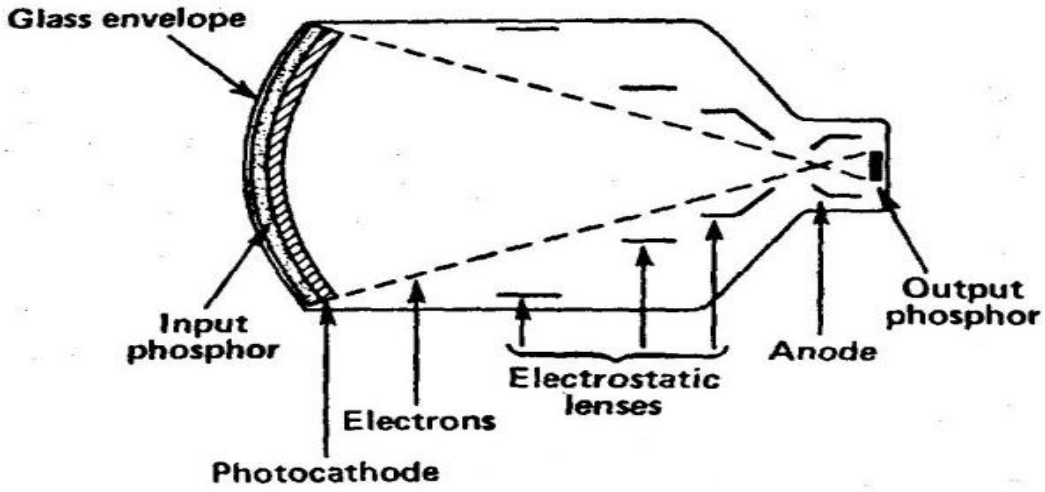
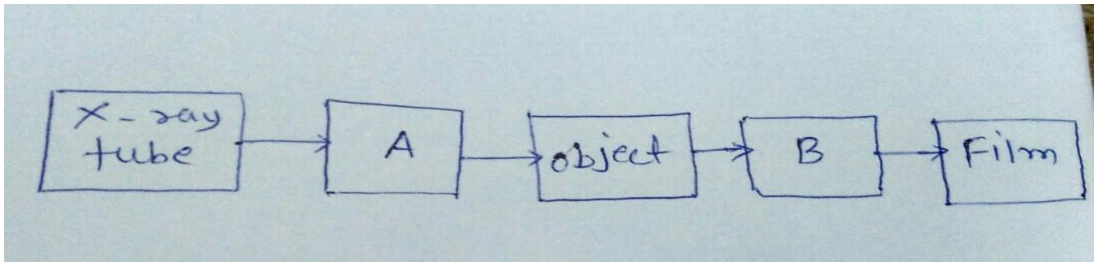
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance. Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

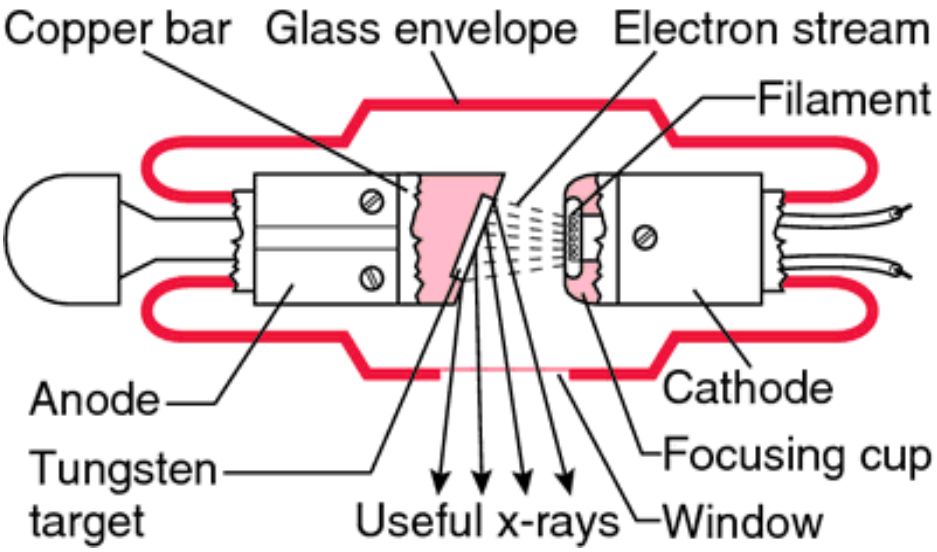
Q. No.	Sub Q. N.	Answer	Marking Scheme
1.		**Attempt any FIVE of the following:**	**10 M**
	a	**Enlist any two types of Electromagnetic Radiations.** **Ans:** **Electromagnetic Radiations:** 1. Gamma rays 2. X-rays	**02 M**
	b	**Explain the need of timer in X-ray machine.** **Ans:** **Need of timer in X-ray machine:** The timer is a device that sets the time for number of seconds for which the tube should be ON.	**02 M**
	c	**Write two image intensifier artifacts.** **Ans:** **Image intensifier artifacts:** **Pincushion distortion:** Pincushion" distortion is primarily caused by the process by which the electrons are focused onto a curved surface within the image intensifier, from which an image is then transferred to a flat plane image intensifier**.** Results in slightly higher magnification of input image towards the edge of the image. **S-distortion:** Is caused by strong external magnetic or electrical fields in close proximity to the image intensifier tube**.** Results the image in a fluoroscopic system to distort with an S shape.	**01 M** **01 M**
	d	**Define RF sheilding.** **Ans:** **Definition of RF shielding:** A Shielding (material copper /steel /aluminium) necessary to prevent noise of radio frequency from entering into the MRI scanner rooms.	**02 M**
	e	**Write any two types of transducer arrays used in ultrasound imaging.** **Ans:** **Transducer arrays used in ultrasound imaging:** 1. Linear sequential array (switched array). 2. Linear phased array (vector, sector).	**01 M** **01 M**

	f	**Write the purpose of PET scan.** **Ans:** **Purpose of PET scan:** Positron Emission tomography is a type of nuclear medicine procedure that measures metabolic activity of cells of body tissues. It helps visualize the biochemical changes taking place in body. It measures blood flow, oxygen use, how the body uses sugar and much more. Thus used to evaluate the function of organs and /or tissues (heart, brain).	**02 M**
	g	**Write the purpose of SPET scan.** **Ans:** **Purpose of SPET scan:** Single Photon Emission Computed Tomography is primarily used to view how blood flows through arteries and veins in brain. Thus it can detect reduced blood flow to injury sites.	**02 M**
2.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Write four medical applications of X-rays.** **Ans:** **Medical applications of X-rays:** 1. Radiation therapy: It is the treatment using penetrating x-rays, on the affected region of the body to destroy the cancer cells. Radiation therapy is a modern treatment technique where the results are faster with fewer side effects than other more traditional forms of treatment. Depending upon the position of the radiation source, different types of treatments are used. 2. Radiography: It is the use of ionizing electromagnetic radiation such as X-rays to view objects. 3. X-rays of bony injuries are looked at by the radiologist for signs of hidden trauma (for example, the famous "fat pad" sign on a fractured elbow). 4. Dental radiography uses a small radiation dose with high penetration to view teeth, which are relatively dense. 5. Mammography is an X-ray examination of breasts and other soft tissues. This has been used mostly on women to screen for breast cancer. 6. Angiography is the use of fluoroscopy to view the cardiovascular system. An iodine-based contrast is injected into the bloodstream and watched as it travels around. Since liquid blood and the vessels are not very dense, a contrast with high density (like the large iodine atoms) is used to view the vessels under X-ray. 7. Dual energy X-ray absorptiometry DEXA, or bone densitometry, is used primarily for osteoporosis tests.	**04 M**
	b	**Explain with sketch the concept of Digital Radiography.** **Ans:** **Digital Radiography:** Digital radiography, also known as direct digital radiography, uses x-ray–sensitive plates that directly capture data during the patient examination, immediately transferring it to a computer system without the use of an intermediate cassette as is the case with computed radiography. Commonly referred to as plates, these flat panel detectors use a combination of amorphous silicon detectors with cesium or gadolinium scintillators that convert X-ray to light which is ultimately translated by thin film transistors into digital data. The images are of the highest quality and are seamlessly sent to a computer display. These systems are popular in dedicated imaging facilities and hospitals with high workloads. Thus digital radiography gives advantages of immediate image preview and availability; elimination of costly film processing steps; a wider dynamic range, which makes it more forgiving for over- and	**02 M**

		under-exposure; as well as the ability to apply special image processing techniques that enhance overall display quality of the image. Also time efficiency through bypassing chemical processing  **Fig: Digital Radiography System**	**02 M**
	c	**Enlist components of CT machine and explain basic principle working of CT machine.** **Ans:** **Components of CT machine:** 1. Gantry 2. Patient table 3. X-ray tube 4. Detector assembly 5. Computer 6. Monitor **Working of CT machine:** Computed tomography (CT) scanning, also known as, computerized axial tomography (CAT) scanning, is a diagnostic imaging procedure that uses x-rays to build cross-sectional images ("slices") of the body. Cross-sections are reconstructed from measurements of attenuation coefficients of x-ray beams in the volume of the object studied. In the particular case of the CT, the emitter of x-rays rotates around the patient and the detector, placed in diametrically opposite side, picks up the image of a body section (beam and detector move in synchrony). Unlike x-ray radiography, the detectors of the CT scanner do not produce an image. They measure the transmission of a thin beam of x-rays through a full scan of the body. The image of that section is taken from different angles, and this allows retrieving the information on the depth (in the third dimension). In order to obtain tomographic images of the patient from the data in "raw" scan, the computer uses complex mathematical algorithms for image reconstruction. The image of the section of the object irradiated by the X-ray is reconstructed from a large number of measurements of attenuation coefficient. It gathers together all the data coming from the elementary volumes of material through the detectors. Using the computer, it presents the elementary surfaces of the reconstructed image from a projection of the data matrix reconstruction, the tone depending on the attenuation coefficients. In conclusion, a measurement made by a detector CT is proportional to the sum of the attenuation coefficients.	**02 M** **02 M**

	d	**Draw piezoelectric ultrasound transducer and describe working of it.** **Ans:**  **Fig : Piezoelectric ultrasound transducer** **Working of Piezoelectric ultrasound transducer:** The transducer is a device that can convert one form of energy into another. Ultrasonic transducers are used to convert an electric signal into ultrasonic energy that can be transmitted into the tissues, and to convert ultrasonic energy reflected back from the tissue into electrical signal. The most important component in ultrasonic transducer is piezoelectric crystal. Piezoelectric materials are made up of numerous dipoles arranged in geometric pattern shown in fig. An electric dipole is a distorted molecule that appears to have a positive charge on one end and negative charge on the other. The positive and negative ends are arranged so that the electrical field will cause them to realign, thus changing the dimensions of crystal shown in the fig .The plating electrodes behave as capacitors. If a voltage is applied in a sudden burst, or pulse, the crystal vibrates and generates sound waves. As the sound pulses passes through the body, echoes reflect back towards the transducer from each tissue interface. These echoes carry energy and they transmit their energy to the transducer, causing a physical compression of the crystal element. This compression forces the tiny dipoles to change their orientation, which induces a voltage between the electrodes. The voltage is amplified and serves as the ultrasonic signal for display on an oscilloscope or television monitor.	**02 M** **02 M**
3.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Draw image intensifier tube and describe its working.** **Ans:** **Working of image intensifier tube:** Image intensifier is use to produce an image bright enough for normal vision and small enough to be coupled to cine, television or spot film camera. Image intensifier tube consists of 1. Input phosphor or photo cathode 2. Electrostatic lens 3. Accelerating anode 4. Output phosphor The image intensifier tube is placed between the patient and fluoroscopy screen. The input fluorescent screen absorbs the X-ray photons. The X-ray photons then interact with the phosphor giving up energy to the outer orbit electrons of phosphor atom. Due to this additional energy atom gets excited. Excited atoms further gives up the surplus energy as visible light photons. These light photons strike the photo-cathode causing it to	**02 M**

		emit photoelectrons. Then these electrons get immediately accelerated towards the anode due to high positive potential applied to the anode with respect to cathode. As the electrons flow toward the anode, they are focused by an electrostatic lens to the output fluorescent screen. The electrons strike this florescent screen that emits the light photons which carry the fluoroscopic image to the observer.  **Fig: Image Intensifier Tube**	**02 M**
	b	**Identify the blocks A and B from figure below and write functions of block A and block B.**  **Ans:** 1. **Block A:** Collimator 2. **Block B:** Grid **Functions of Collimator:** In order to reduce the dose of x-rays to the patient, the beam should not strike any more on the body than necessary. It consists of a sheet of lead with a circular or rectangular hole of suitable size. It may consist of four adjustable lead strips which can be moved relative to each other. 1. The necessary shaping of the beam is done with collimator. As the collimator is placed between the x-ray tube and the patient. 2. This results in low dose to the patient and simultaneously increases the contrast, because less scattered radiation reaches the image plane. **Functions of Grid**: It is the most effective way of removing scattered radiations. It consists of lead foils & separated by a transparent spacer. Leads are characterized by grid ratio. It is the ratio of height of lead strips to distance between them. They are of two types linear & crossed. 1. They are used to absorb scattered radiation. 2. Improve image contrast. (any other relevant answer should be consider as a valid answer)	**02 M** **01 M** **01 M**

	c	**Describe procedural steps of Maintenance for MRI machine.** **Ans** **Maintenance for MRI machine:** 1. Clean the flooring. 2. Clean the MRI table and controls .Do not use water on the MRI equipment. Use a dry cloth adding spirit if marks must be removed. 3. It should become a practice to inspect all areas of shielding. The MRI system obtains raw data through interpretation of RF information and rooms must be shielded from all external RF signals. 4. Inspect the door on regular basis to ensure shielding elements are intact and surface are clean and inspect the penetration panel to ensure no cable connections or shielding plates have become loose . 5. Regularly monitor the helium level of the machine. 6. Check the interface between machine and console room.	**04 M**
	d	**X-ray is having Kvp rating of 50Kvp, Milliampere rating of 50mA and X-ray emits for 9 second. Calculate heat unit value (HU) for this tube.** **Ans:** Given, 50 Kvp, 50 mA, 9 second. **Heat Unit (HU) = KVp*mA*S** = 50*50*9 = **22500**	**02 M** **02 M**
4.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Draw sketch of Stationary Anode tube and give functions of the control knobs.** **i) Exposure Switch** **ii) Timer knob** **Ans:**  **Fig: Stationary anode tube** **Exposure Switch:** Push button switches to initiate exposure when the pushbutton is depressed. If the switch is released during an exposure cycle, the exposure will automatically be terminated. **Timer knob:** Provides the selection of eighteen position radiographic exposure values from 1/120 to 6.0 seconds.	**02M** **01 M** **01 M**

b **State the causes of faults occurring in an ultrasound scanner.**

i. **Machine does not work**
ii. **Ultrasound does not generate of required frequency**
iii. **Image quality is poor.**
iv. **Display is poor**

Ans:

Faults	Causes
Machine does not work	1. No power from mains socket. 2. Electrical cable fault.
Ultrasound does not generate of required frequency	1. Transducer probe. 2. Transducer pulse controls section fault.
Image quality is poor.	1. Insufficient gel. 2. Controls set incorrectly. 3. Main voltage is too low. 4. Probe/display problem.
Display is poor	1. Cable damage. 2. Acoustic array damage. 3. Electronic failure.

Table: Causes of faults occurring in an ultrasound scanner

04 M

c **Write the risks involved in handling X-ray machine.**

Ans:

Risks involved in handling X-ray machine:

1. High dose can cause reddening of the skin or erythema.
2. X rays are highly absorbed in soft tissue, and severe burns can result from exposure of the hands, arms, skin or eyes to the direct or diffracted beams.
3. Loss of hair or epilation.
4. If a large area of skin is irradiated, erythema and pigmentation will occur with the pigmentation eventually fading.
5. If enough radiation of the proper energy is absorbed in the skin this will result in permanent destruction of either hair or sweat glands, or whole skin, with a resulting scar.
6. It can cause chronic radiation dermatitis, Radiation cancer.
7. It can affect fetus if it is used for pregnant women.

04 M

d **Enlist the components of MRI system and write the risks involved in handling the MRI machine.**

Ans:

Components of MRI system:

1. Primary Magnet
2. Gradient Magnet
3. R.F. equipment
4. Computer
5. Data Storage
6. Display and control

02 M

Risks involved handling MRI machine:

1. Medical Alert cards should be checked of patients.
2. Cards state whether or not implant of patient is MRI compatible.
3. Cards should be checked by radiologists.
4. There is possible damage to MRI scanner due to ferromagnetic objects as they magnetize. Hence should not be possessed by technologists or patient entering

		the MRI room. 5. It takes 4 days to remove the object and to repower the scanner. 6. Noise : Loud noise due to magnets is generated while undergoing an MRI scan hence special ear protections must be provided to the patients 7. Metallic chips, materials, surgical clips, or foreign material (artificial joints, metallic bone plates, or prosthetic devices, etc.) can significantly distort the images obtained by the MRI scanner. 8. Patients who have heart pacemakers, metal implants, or metal chips or clips in or around the eyeballs cannot be scanned with an MRI because of the risk that the magnet may move the metal in these areas.	**02 M**
	e	**Write installation steps for Angiography machine.** **Ans:** **Installation of Angiography machine:** 1. Prepare lab area layout. 2. Unpack the box. 3. Read the user manual carefully. 4. Check environmental condition of room. 5. Check electrical supply of the room. 6. Assemble all the accessories of equipment 7. Mount TV camera, heat exchanger, power supply, X-ray tube and attached assembly cover, C- arm unit, driver unit, image intensifier tube. 8. Install control cabinet & mount display unit. 9. Please check alignment of X-ray beam mount collimator & check its alignment. 10. Install other optional components like monitor support, remote console, console car. 11. Check the settings, inspect all the connection. 12. Perform demo test.	**04 M**
5.		**Attempt any <u>TWO</u> of the following:**	**12 M**
	a	**Enlist any three Image Reconstruction Techniques in CT and explain any one technique with a neat sketch.** **Ans:** **Image reconstruction Techniques in CT:** 1. Back projection reconstruction technique. 2. Filtered back projection technique. 3. Iterative reconstruction technique. 4. Fourier reconstruction technique. **Back projection reconstruction technique:** Back projection some times called the 'summation method' which demonstrates a two dimensional reconstruction of a cross cut from the center of a solid block. The block is scanned from both the top &left sides by a moving X-ray beam to produce the image profile shown in fig. the image profile look like steps. The height of the steps is proportional to the amount of radiation passed through the block. The center transmitted the most radiation, so it is the highest step in the image profile. The steps are then assigned to a gray scale density. That is proportional to their height. These densities are arranged in rows, called 'Rays'. The width of the rays is the same as the width of the steps in the profile .The ray length is equal to the height of the original object. In back projection produces a crude reproduction of the original object.	**02 M** **02 M**

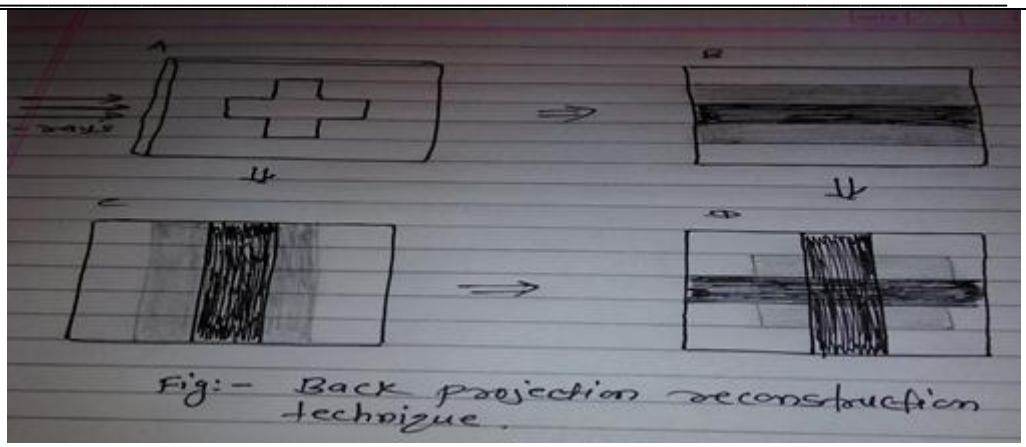


Fig: Back projection reconstruction technique

02 M

Filtered back projection technique:

Filtered back projection is similar to back projection expect the image is filtered or modified to exactly counterbalance the effect of sudden density changes , which causes blurring (the star pattern) in simple back projection. In this technique the projected information is filtered much like light is filtered by a polarizing lens. The fig shows a two dimensional filtered back projection of a square object. The density of the projected rays is adjusted to compensate for the star effect.

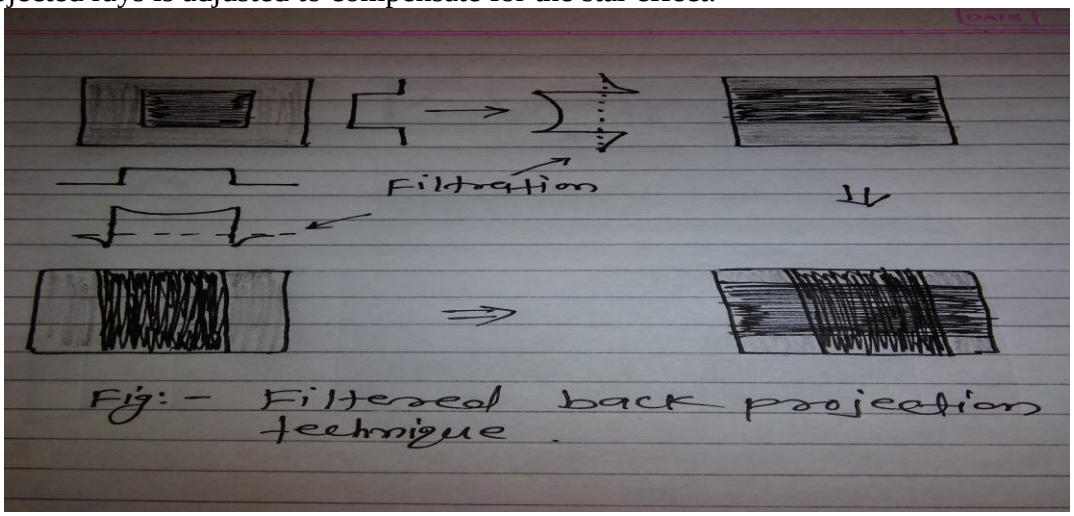


Fig: Filtered back projection technique

Iterative reconstruction technique:

In the iterative reconstruction for a four element square. Horizontal, vertical, & diagonal ray sums are shown in the adjacent blocks. In the first step, the two horizontal ray sums (16 &6 in the hatched blocks) are divided equally among the two elements in the ray. If the ray sums had represented 10 elements, the sum would have been divided equally among all 10 elements. Next the new numbers in the vertical row are added to produce the new ray sum (11 &11 in the shaded blocks) and compared with the original measured ray sums ((also in shaded blocks). The difference between the original & new ray sums (10-11= -1 and 12-11= +1) is divided by the number of elements in the ray (-1/2 = -0.5 and +1/ 2 = +0.5).These differences are algebraically added to each element (8-0.5 =7.5 , 3-0.5 =2.5 , 8+ 0.5 = 8.5 , and 3+ 0.5 = 3.5) The process is repeated for diagonal ray sums to complete the first iteration.

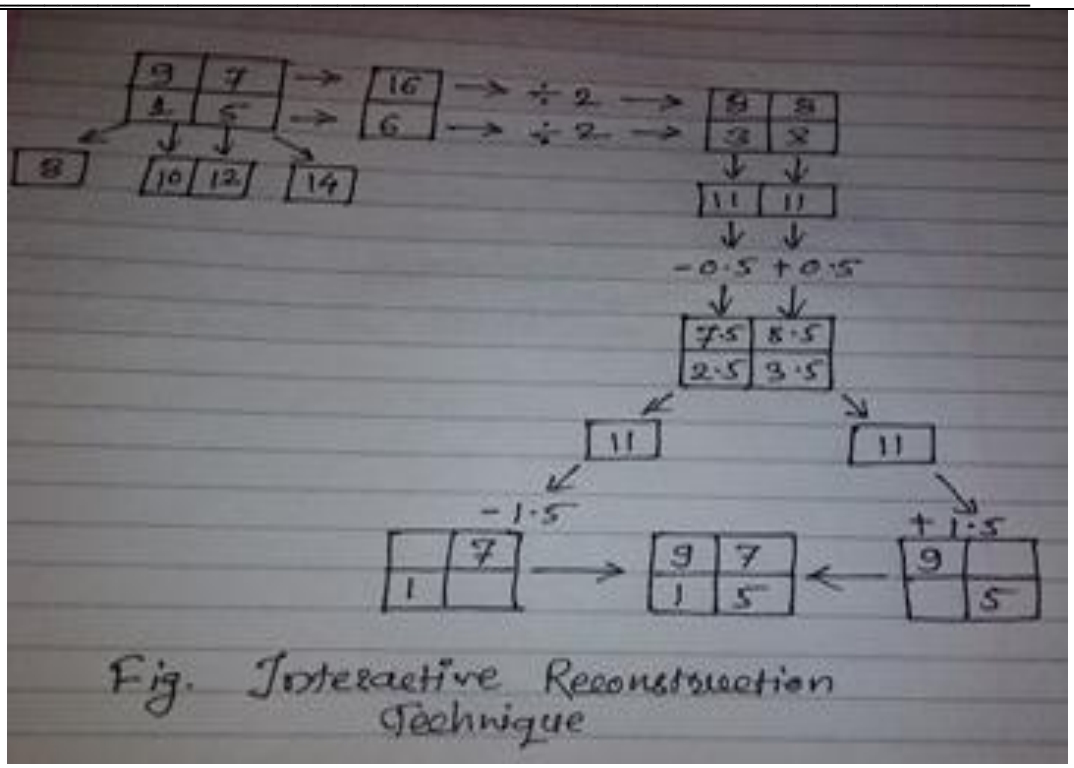


Fig: Iterative reconstruction technique

Fourier reconstruction technique:

The basis of Fourier analysis is that any function of time or space can be represented by the sum of various frequencies and amplitudes of sine and cosine waves. The ray projections are shown with squared edges , which is the most difficult wave form to reproduce . The actual projected images would be more rounded than those shown, which would simplify a Fourier reconstruction. The last reconstruction represents the sum of eight cosine waves, but only the first four steps are shown in fig. This type of mathematical manipulation is easily and quickly processed in a computer.

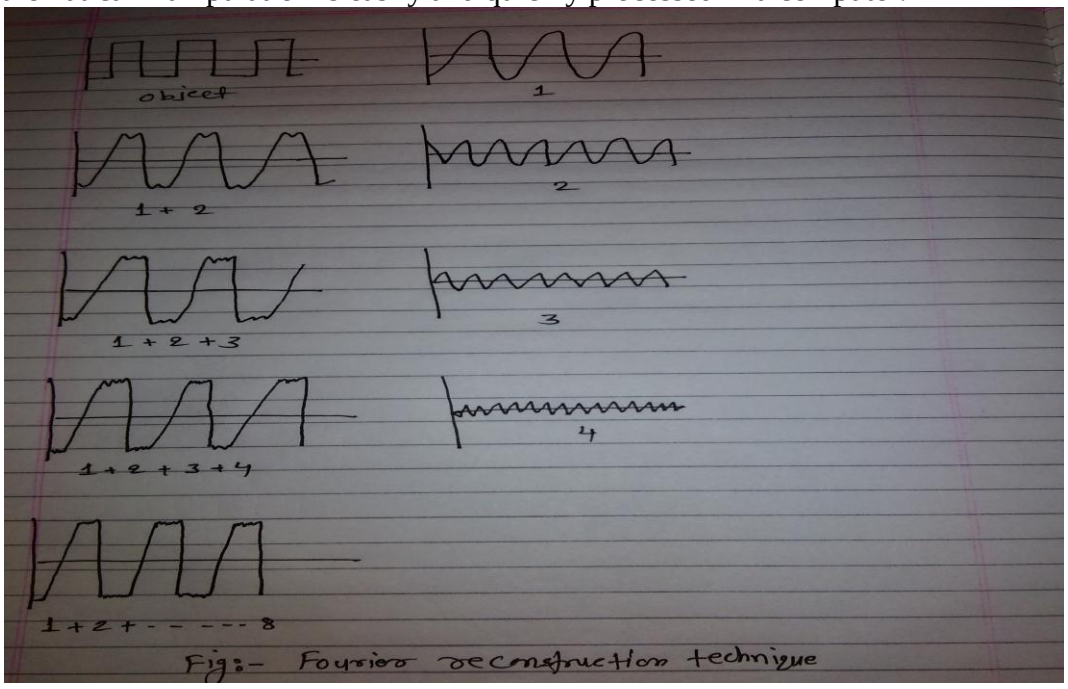
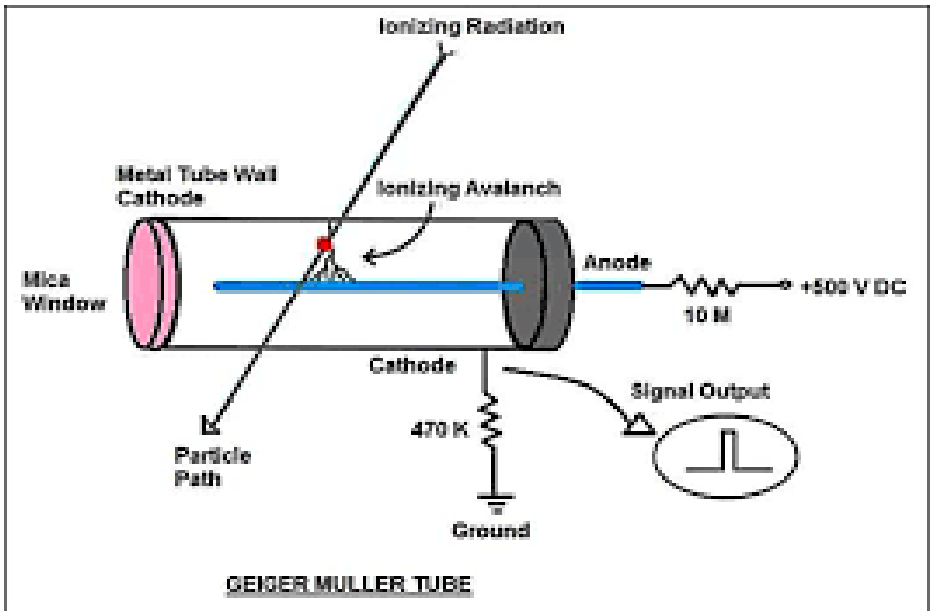
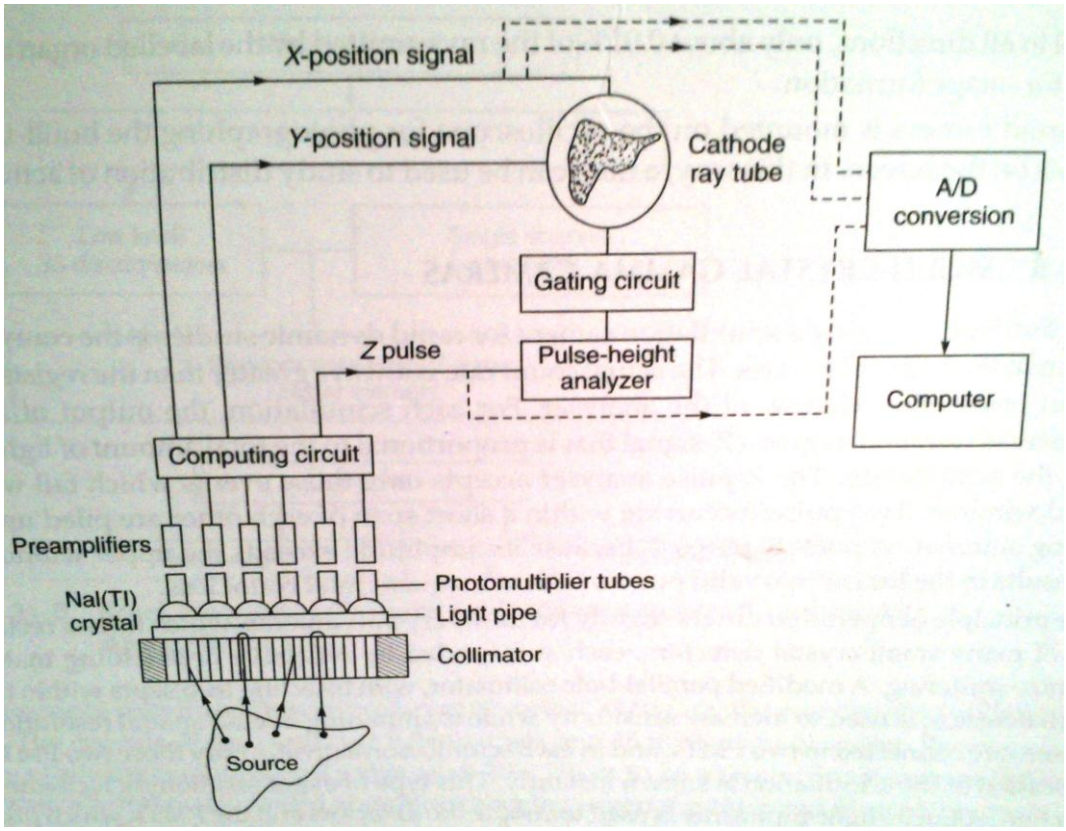


Fig: Fourier reconstruction technique

	b	**Enlist different ultrasound scan modes. Describe TM scan mode.** **Ans:** **Ultrasound scan modes:** 1. A-mode Amplitude mode 2. B-mode Brightness mode 3. T-M mode (Time motion) scan mode **Time motion (TM) scan mode:** Is very useful in monitoring moving structures inside the body. It is basically combination of A-scan and B-scan. It is modified arrangement employed to display a moving target and obtain its speed of movement and range of movement. In this system intensity or brightness of the beam is modulated using received echoes and displayed on horizontal axis with the help of horizontal timing information, that is horizontal sweep. It is moved up or down by making use of slow vertical sweep, resulting into time motion recording of moving structures. This is how ;a moving object traces a characteristic curved line and gives details of range of movement, slope of position on x-y axis and speed of movement.	**03 M** **03 M**
	c	**Enlist two Nuclear Transducers and describe any one with sketch.** **Ans:** 1. Geiger Muller tube detector 2. Scintillation counter / detector  Geiger Muller tube The Geiger–Müller tube or G–M tube is the sensing element of the Geiger counter instrument used for the detection of ionizing radiation. It is a gaseous ionization detector and uses the Townsend avalanche phenomenon to produce an easily detectable electronic pulse from as little as a single ionizing event due to a radiation particle. It is used for the detection of gamma radiation, X-rays, and alpha and beta particles. It can also be adapted to detect neutrons. The tube operates in the "Geiger" region of ion pair generation. G-M tube consists of a chamber filled with a gas mixture at a low pressure of about 0.1 atmospheres. The chamber contains two electrodes, between which there is a potential difference of several hundred volts. The walls of the tube are either metal or have their inside surface coated with a conducting material or a spiral wire to form the cathode, while the anode is a wire mounted axially in the centre of the chamber. When ionizing radiation strikes the tube, some molecules of the fill gas are ionized directly by the incident radiation, and if the tube cathode is an electrical conductor, such	**02 M** **02 M** **02 M**

		as stainless steel, indirectly by means of secondary electrons produced in the walls of the tube, which migrate into the gas. This creates positively charged ions and free electrons, known as ion pairs, in the gas. The strong electric field created by the voltage across the tube's electrodes accelerates the positive ions towards the cathode and the electrons towards the anode. Close to the anode in the "avalanche region" where the electric field strength rises exponentially as the anode is approached, free electrons gain sufficient energy to ionize additional gas molecules by collision and create a large number of electron avalanches. These spread along the anode and effectively throughout the avalanche region. This is the "gas multiplication" effect which gives the tube its key characteristic of being able to produce a significant output pulse from a single original ionizing event.	
6.		**Attempt any <u>TWO</u> of the following:**	**12 M**
	a	**Draw block diagram of gamma camera and describe its working.** **Ans:**  **Fig : Gamma Camera** The gamma camera is a stationary imaging device as opposed to the rectilinear scanner in which the detector is made to move over the organ of interest. It consists of following functional components. Detector: This consists of a collimator, crystal, photomultiplier tubes, and position localization circuitry. When a photon of the radiation leaves the patient body it passes through the collimator and interacts a crystal wherein its energy is converted into light. The light from the crystal is received by photomultiplier tubes and converted into an electrical signal. The electrical signal passes through the position localization circuitry whose output consists of x and y positional signals and a energy signal. Hundreds of thousands of photons leave the patient's body and strike crystal, each causing a black spot to be formed on the film.	**03 M** **03 M**

	b	**Define Doppler effect and explain principle of working of Doppler Ultrasound machine.** **Ans:** **Definition of Doppler effect:** An apparent change in the frequency of waves, as of sound or light, occurring when the source and observer are in motion relative to each other, with the frequency increasing when the source and observer approach each other and decreasing when they move apart. **Working of Doppler Ultrasound machine:** Doppler ultrasound machine is based upon the Doppler Effect. When the object reflecting the ultrasound waves is moving, it changes the frequency of the echoes, creating a higher frequency if it is moving toward the probe and a lower frequency if it is moving away from the probe. How much the frequency is changed depends upon how fast the object is moving. Doppler ultrasound measures the change in frequency of the echoes to calculate how fast an object is moving. Doppler ultrasound has been used mostly to measure the rate of blood flow through the heart and major arteries.	**03 M** **03 M**
	c	**Write installation steps for C-arm machine and write safety tips for C-arm fluoroscopy.** **Ans** **Installation steps for C-arm machine:** 1. Removal of packing material 2. Check packing list 3. Install work station wheels 4. Installation of mainframe wheel outer casing 5. Install Handle(NOTE: According to C-arm arc choose the corresponding handle) 6. Handle " Lock Release" demo 7. Turn Handle demo 8. Signal cable connection 9. Install beam limiting device 10. Install and connect the work station 11. Installation of handheld controller 12. Connect the power cord 13. Connect radiation control lines 14. Install film clip 15. Close the workstation and host power. **Safety tips for C-arm fluoroscopy:** 1. Talk to your patient about the radiation risks. 2. Try to reduce the amount of radiation exposure. 3. Adjust distance. Your patient's exposure to radiation increases exponentially by how close the patient is to the x-ray tube. Try to position your patient as far as possible from the tube 4. Shorten the fluoro times. 5. Unauthorized personnel should not be in the room during the fluoroscopy. . 6. Analyze original radiographs before performing the fluoroscopic examination. This can reduce the repeat rate for the time required for the procedure. 7. Stand on the image intensifier side of the C-Arm when performing the procedure. This will avoid radiation leakage from the x-ray tube. 8. Be sure to step away from the patient during the fluoroscopy. Placing yourself one foot further (or more) from the patient will reduce the amount of radiation	**03 M** **03 M**

		you are exposed to. 9. Shield yourself as much as possible. Leaded eyewear with side shields can protect the lens or your eyes. You should also wear leaded gloves and wear a wrap-around apron which will keep the lead between you and the x-ray tube. 10. Install structural shielding to reduce radiation. This could be a lead acrylic shield that is under the table or even mounted on the ceiling.	