

## **PHYS 1200 Physics of Everyday Experience**

### **Review questions and exercises for Lecture 34 (MP-2)**

1. What is the Heisenberg uncertainty principle?
2. What is an x-ray image?
3. What is the difference between x-rays and gamma rays? Give examples of the sources of both.
4. What are the differences between light produced by a laser and ordinary light sources? What process is involved in producing laser light?
5. What is tomography and how is it used to make a CAT scan?
6. What are the advantages of MRI over a CAT scan?
7. What physical process is used in MRI?
8. Why must all iron objects be prohibited from the area around an MRI device?
9. What types of electromagnetic radiations are used in a CAT scan and an MRI?
10. How are lasers used to correct vision problems?

Answers:

1. The Heisenberg uncertainty principle states that it is impossible to determine the position and velocity of an electron simultaneously with unlimited accuracy. An electron is detected by bouncing photons from it. However, when the photon interacts with the electron, it alters its characteristics (position and velocity). Thus at the microscopic level, measurements are limited by the fact that the measurement process itself alters the system that one is attempting to measure. This is a fundamental limitation of nature.
2. X-rays generally do not penetrate through dense tissue like bones. Thus an x-ray image shows the shadows of the denser material in the body.
3. X-rays and gamma rays are both electromagnetic waves, but gamma rays are considerably more energetic than x-rays. X-rays are produced when accelerated electrons are suddenly stopped in a material. Gamma rays are produced by naturally radioactive materials or in cosmic rays that constantly bombard the upper atmosphere.
4. Ordinary light is incoherent whereas laser light is coherent. Ordinary light usually consists of a broad spectrum of wavelengths whereas laser light is single wavelength. Ordinary light tends to spread out from its source whereas laser light remains in a narrow beam.
5. Tomography is a computer process in which images taken from many different angles are assembled into a 3-D image. In a CAT scan, several x-ray images are taken through different slices of the body. These image slices are then assembled into a 3-D image using computer algorithms. This provides a cross sectional view of the organs.
6. An MRI generally is better for obtaining images of soft tissue. This is why the MRI is used for muscle or tendon issues. Also the MRI does not expose the body to x-rays as in a CAT scan.
7. MRI uses the magnetic properties of the hydrogen atoms in the body. The protons are atomic magnets whose orientation can be altered when placed in a high magnetic field.
8. The magnet in the MRI device produces a field that is 100,000 times stronger than the earth's magnetic field. This large field will exert enormous forces on any objects made of iron.
9. A CAT scan uses x-rays whereas an MRI uses harmless radio waves.
10. Lasers are used in eye surgery to very precisely remove tissue from the cornea. This allows the surgeon to change the shape of the cornea.