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## ***Program Support Notes***

**Senior Secondary**

**27 mins**

# **The Physics of Medical Imaging**

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**Suitable for:**

**Physics**

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# The Physics of Medical Imaging

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## For Teachers:

### Introduction

This program introduces senior students to some of the modern methods used in medicine and the part physics has played in developing these methods. Excellent graphics are provided for students to gain a sound understanding of terms and apparatus used in medical treatments. The basic ideas of the more common medical treatments are covered in detail with clear explanations of the various diagnostic and treatment processes used today. Students will also see how the properties of various waves in the electromagnetic spectrum and high frequency sound waves are utilised in medicine. Explanations of CT scanning, PET scanning, ultrasound and the use of x-rays are given in detail.

### Program Timeline

00:00:00	Introduction
00:01:21	Ultrasound
00:06:53	Electromagnetic Waves – X-Rays – CAT Scans
00:12:35	Radioactivity - PET
00:18:41	Electromagnetism - MRI
00:24:49	Conclusion
00:26:04	Credits
00:27:24	End Program

### Useful Resources

- Magnetic Resonance Imaging by Stark and Bradley, second edition (Artifacts, Basics,)
- Clinical Magnetic Resonance Imaging and Spectroscopy by Andrew et al. (Basics, Spectroscopy).
- The Essential Physics of Medical Imaging by Bushberg et al. (Basics).

### Other Relevant Programs available from VEA

- Catching the Sun – The Physics of Solar Energy
- Energy Rules – The Conservation of Energy and Momentum

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## Student Worksheet:

### **Before Viewing the Program**

1. Explain to the person next to you the difference between invasive and non-invasive surgery. Give an example of a non-invasive surgical process.
2. Machines of various types are now some of the main tools used by doctors to investigate and to treat disease. In small groups, discuss as many types of machines used by medical practitioners that your group can name and list their various advantages and disadvantages.
3. Using the internet, or other suitable reference, provide a 100 word report on *Physics in Medical Imaging*. In your report, list and describe briefly some of the various machines that are used and the purposes that they are used for.

# The Physics of Medical Imaging

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## While Viewing the Program

1. Explain the term 'non-invasive surgery'

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2. What are the four kinds of applications used in medical imaging?

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3. Ultrasound is beneficial in detecting fluid in body organs and structures where fluid should not exist. Give one example of a diagnosis which supports this fact.

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4. Ultrasound uses sound waves. Are these sound waves high, or low frequency?

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5. Ultrasound uses two types of scan. Name these two types and identify which scan is amplitude based?

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6. X-rays are electromagnetic radiation of long wavelength and small energy. Re-write this statement correctly.

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7. Name two precautions necessary for workers in the radiological field.

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## The Physics of Medical Imaging

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8. Describe the difference between 'hard' and 'soft' x-rays.

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9. CT scans use a higher dose of x-rays than normal x-ray scans. What is the advantage of a CT scan over a normal x-ray scan?

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10. PET scans can be used to track the metabolism of organs in the human body. What do the letters P.E.T. stand for?

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11. A radiopharmaceutical is injected into a patient prior to a PET scan. These radiopharmaceuticals decay emitting positrons which meet electrons and both are annihilated producing radiation. What type of radiation is produced?

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12. Name two uses for MRI scans.

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13. Which disease is very difficult to diagnose but can be detected with MRI?

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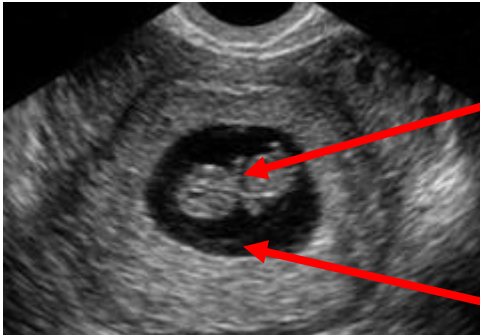
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## After Viewing the Program

1. Complete the following table by placing a tick in either the true or false box:

Question	True	False
Ultrasound uses high frequency sound waves for diagnosis.		
Ultrasound is good at detecting the presence of fluid in soft body structures.		
Ultrasound cannot be used to check human foetus development.		
As the frequency of a photon of electromagnetic radiation increases, the photon energy increases.		
X-ray photons are short wavelength electromagnetic radiation.		
CT scans use x-rays to produce images of human body structures.		
PET scans use x-rays to produce images of human body structures.		
MRI is very good for investigating soft-tissue injuries to the human body.		
CT scans have advantages over ultrasound and normal xray scans because a CT scan can see inside hard structures whereas the other two cannot.		

2. This ultrasound scan shows an 8 week old human foetus. Label the parts indicated by arrows.



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\_\_\_\_\_

## The Physics of Medical Imaging

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3. Match the medical physics job with the part of the electromagnetic spectrum used (each word can be used more than once or not at all)

Imaging a fracture in a bone	Gamma rays ( $\gamma$ )
Treating cancer	X-rays
CT scans	Infra Red (IR)
Bone scan	Ultraviolet (UV)

4. Radiotherapy- Use the words underlined below to complete the following paragraph.

healthy      dividing      kill      cancerous      DNA

X-rays and other radiation can damage the \_\_\_\_\_ in cells and kill them.

Cells which are \_\_\_\_\_ rapidly are more likely to be killed, so we use x-

x-rays to \_\_\_\_\_ the rapidly- \_\_\_\_\_ cells. We

must make sure that \_\_\_\_\_ tissue is undamaged.

5. Which of these isotopes would be suitable for use as a tracer? Circle your choice.

$^{14}\text{C}$	carbon-14	half-life: 5730 years
$^{57}\text{Co}$	cobalt- 57	half-life: 271 days
$^{99\text{m}}\text{Tc}$	technetium-99m	half-life: 6hours
$^{15}\text{O}$	oxygen-15	half-life: 2mins

- a) Justify your choice of radioisotope?

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6. What type of radiation do the isotopes used in PET scans emit?

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7. What happens when this particle meets an electron?

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8. What is then produced?

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# The Physics of Medical Imaging

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## Suggested Student Responses

### While Viewing the Program

1. Explain the term 'non-invasive surgery'  
**Non-invasive surgery is a procedure for an illness that does not involve cutting into the body for diagnosis or treatment.**
2. What are the four kinds of applications used in medical imaging?  
**The four kinds of applications used in medical imaging are ultrasound, electromagnetic radiation (x-rays), radioactivity and MRI.**
3. Ultrasound is beneficial in detecting fluid in body organs and structures where fluid should not exist. Give one example of a diagnosis which supports this fact.  
**Ultrasound is beneficial in detecting fluid in body organs and structures where fluid should not exist. Ultrasound is also beneficial in detecting a cyst containing parasites in the fluid as well as identifying fluid on the lung.**
4. Ultrasound uses sound waves. Are these sound waves high, or low frequency?  
**These sound waves are of high frequency.**
5. Ultrasound uses two types of scan. Name these two types and identify which scan is amplitude based?  
**Ultrasound uses two types of scan. These two types are called A and B scans. A scans are amplitude based.**
6. X-rays are electromagnetic radiation of long wavelength and small energy. Re-write this statement correctly.  
**X-rays are electromagnetic radiation of short wavelength and high energy.**
7. Name two precautions necessary for workers in the radiological field.  
**Two precautions necessary for workers in the radiological field are lead aprons and radioactivity sensors**
8. Describe the difference between 'hard' and 'soft' x-rays.  
**Hard x-rays are of higher energy than soft x-rays.**
9. CT scans use a higher dose of x-rays than normal x-ray scans. What is the advantage of a CT scan over a normal x-ray scan?  
**The advantage of a CT scan over a normal x-ray scan lies in the fact that x-ray penetration is greater giving a clearer image.**
10. PET scans can be used to track the metabolism of organs in the human body. What do the letters P.E.T. stand for?  
**PET scans can be used to track the metabolism of organs in the human body. P.E.T. stands for positron emission tomography**
11. A radiopharmaceutical is injected into a patient prior to a PET scan. These radiopharmaceuticals decay emitting positrons which meet electrons and both are annihilated producing radiation. What type of radiation is produced?  
**The type of radiation is gamma radiation and two gamma rays are produced which move in opposite directions.**
12. Name two uses for MRI scans.  
**MRI scans are very useful in detecting soft tissue problems in joints and structures.**
13. Which disease is very difficult to diagnose but can be detected with MRI?  
**Multiple sclerosis is very difficult to diagnose but can be detected with MRI.**



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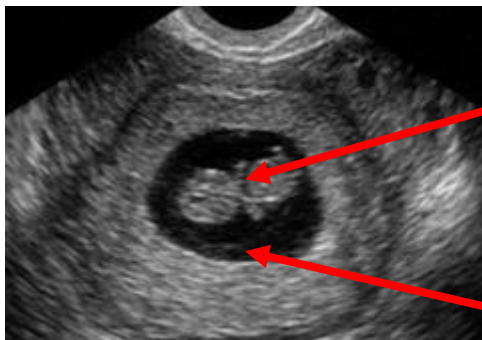
## Suggested Student Responses

### After Viewing the Program

1. Complete the following table by placing a tick in either the true or false box:

Question	True	False
Ultrasound uses high frequency sound waves for diagnosis.	√	
Ultrasound is good at detecting the presence of fluid in soft body structures.	√	
Ultrasound cannot be used to check human foetus development.		√
As the frequency of a photon of electromagnetic radiation increases, the photon energy increases.	√	
X-ray photons are short wavelength electromagnetic radiation.	√	
CT scans use x-rays to produce images of human body structures.	√	
PET scans use x-rays to produce images of human body structures.		√
MRI is very good for investigating soft-tissue injuries to the human body.	√	
CT scans have advantages over ultrasound and normal x-ray scans because a CT scan can see inside hard structures whereas the other two cannot.	√	

2. This ultrasound scan shows an 8 week old human foetus. Label the parts indicated by arrows.



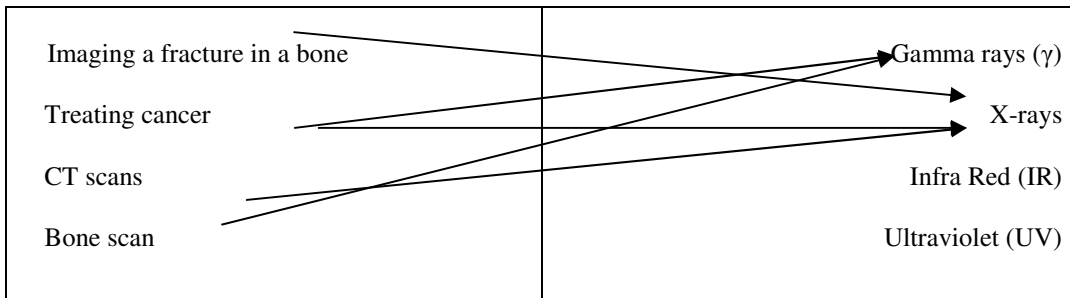
Foetus

Fluid

## The Physics of Medical Imaging

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3. Match the medical physics job with the part of the electromagnetic spectrum used (each word can be used more than once or not at all)



4. Radiotherapy- Use the words Healthy, dividing, kill, cancerous, DNA

X-rays and other radiation can damage the **DNA** in cells and kill them. Cells which are **dividing** rapidly are more likely to be killed, so we use X-rays to **kill** the rapidly-dividing **cancerous** cells. We must make sure that **healthy** tissue is undamaged.

5. Which of these isotopes would be suitable for use as a tracer? Circle your choice.

$^{14}\text{C}$	carbon-14	half-life: 5730 years
$^{57}\text{Co}$	cobalt- 57	half-life: 271 days
$^{99\text{m}}\text{Tc}$	<b>technetium-99m</b>	half-life: 6hours
$^{15}\text{O}$	oxygen-15	half-life: 2mins

- a) Justify your choice of radioisotope?

**Technetium-99 is the best choice as it has a suitable half-life of 6 hours. Oxygen-15 decays too quickly and both carbon-14 and cobalt-57 have half-lives that are too long.**

6. What type of radiation do the isotopes used in PET scans emit?  
**The type of radiation emitted by the isotopes used in PET scans is positrons (positively charged electrons).**
7. What happens when this particle meets an electron?  
**When this particle meets an electron there is mutual annihilation.**
8. What is then produced?  
**Two oppositely moving gamma rays are emitted.**