

<b>Unit Title:</b>	Medical Physics
<b>Unit Level:</b>	Three
<b>Unit Credit Value:</b>	3
<b>Unit Code:</b>	WNI456
<b>Unit Type:</b>	Academic Subject Content
<b>Unit Review Date:</b>	31/12/2028
<b>Graded / ungraded :</b>	Graded

### This unit has 6 learning outcomes

Learning outcomes	Assessment criteria
The learner will:	The learner can:
1. Understand atomic structure.	1.1. Describe the fundamental differences between protons, neutrons and electrons in terms of mass and charge.
2. Understand the nature of alpha, beta and gamma radiation, and X-rays.	2.1. Explain how the range in air and penetrating powers of alpha, beta, gamma and x-rays are related to their nature and properties. 2.2. Explain the safety procedures followed when using alpha, beta and gamma radiation and x-rays.
3. Understand the main uses of ionising radiation in monitoring and treatment.	3.1. Explain the use of the Barium meal for soft body imaging. 3.2. Explain the use of $\gamma$ -rays in imaging. 3.3. Explain the use of internal sources of radiation in treatment procedures.
4. Understand how radio isotopes are used in health care.	4.1 Explain how technetium-99m is generated. 4.2 Explain the use of Iodine-131 in thyroid investigations.
5. Understand the health applications of a selected part of electromagnetic spectrum.	5.1. Explain medical uses of parts of the electromagnetic spectrum.
6. Understand how ultrasound and magnetic resonance imaging are used in health care.	6.1. Explain the use of ultrasonics in medical imaging and treatment. 6.2. Explain the use of magnetic resonance in medical investigations.

### Assessment (Graded)

- |   |                 |
|---|-----------------|
| 1. Meets assessment criteria  | At least a Pass |
| 2. Further grading  |                 |
| <ul style="list-style-type: none"> <li>▪ Meets assessment criteria but not merit grading standards</li> </ul> | Pass            |

- Meets assessment criteria and merit but not distinction grading standards      Merit
- Meets assessment criteria and distinction grading standards      Distinction

## Indicative content

The following content is to be included in the delivery of the unit.

Learning outcomes	Indicative content
1.1 Describe the fundamental differences between protons, neutrons and electrons in terms of mass and charge.	<ul style="list-style-type: none"> <li>• Proton – positive charge and mass of <math>1.673 \times 10^{-27}\text{Kg}</math></li> <li>• Neutron – no charge and mass of <math>1.674 \times 10^{-27}\text{Kg}</math></li> <li>• Electron – negative charge and a mass of <math>9.1 \times 10^{-31}\text{Kg}</math></li> </ul>
2.1 Explain how the range in air and penetrating powers of alpha, beta, gamma and x-rays are related to their nature and properties.	<ul style="list-style-type: none"> <li>• Alpha particle – large, slow moving in air, unable to penetrate deep due to relative size</li> <li>• Beta particle – fast moving electron, relatively strong penetrating power.</li> <li>• Gamma rays – no mass just energy, very fast moving in air and high penetrating power.</li> <li>• X rays are not as fast and have less penetrating power due to having lower energy.</li> </ul>
2.2 Explain the safety procedures followed when using alpha, beta and gamma radiation and x-rays.	<ul style="list-style-type: none"> <li>• Use of PPE (e.g, gloves, protective eye wear and clothing)</li> <li>• Storage and disposal of PPE to avoid contamination.</li> <li>• Safety equipment – (e.g. handle with tongs, physical protection equipment such as shielding)</li> <li>• Exposure times to limit exposure the radioactive material</li> <li>• Storage using suitable shielded containers.</li> <li>• Risk assessment to ensure the above are all carried out and regular monitoring using logs.</li> </ul>
3.1 Explain the use of the Barium meal for soft body imaging.	<ul style="list-style-type: none"> <li>• Barium Meal Procedure – different stages</li> <li>• The purpose of the barium meal in imaging.</li> </ul>

<p>3.2 Explain the use of <math>\gamma</math>-rays in imaging.</p>	<ul style="list-style-type: none"> <li>• Procedure for Positron Emission Topography (PET)</li> <li>• Procedure for Single-Photon Emission Computed Tomography (SPECT)</li> </ul>
<p>3.3 Explain the use of internal sources of radiation in treatment procedures.</p>	<p>Placement of radiation therapy (called Brachytherapy) including:</p> <ul style="list-style-type: none"> <li>• Placement of radioactive source close to or within a tumour to target cells or tissue to be destroyed.</li> <li>• Targeted and high dose concentrations to avoid destroying other healthy tissue and cells.</li> <li>• Reducing side effects c.f. external radiation treatment.</li> <li>• Targeted sources of radiation means that higher doses can be administered.</li> </ul>
<p>4.1 Explain how technetium-99m is generated.</p>	<ul style="list-style-type: none"> <li>• Formation from Molybdenum-99</li> <li>• Decaying to Technetium-99 via beta decay.</li> <li>• Process of extraction and purification for medical use.</li> </ul>
<p>4.2 Explain the use of Iodine-131 in thyroid investigations.</p>	<ul style="list-style-type: none"> <li>• Iodine-131 emits both beta and gamma particles.</li> <li>• The beta particles destroy target treatment</li> <li>• The gamma particles are used to generate imagery using external detectors.</li> <li>• The thyroid is a unique body organ that concentrates the iodine within it from the bloodstream thereby absorbing the iodine and avoiding other parts of the body being contaminated</li> <li>• Iodine-131 is administered orally for the treatment of thyroid conditions.</li> <li>• Common thyroid conditions treated this way are thyroid cancer and hyperthyroidism (over-active thyroids)</li> </ul>
<p>5.1 Explain medical uses of parts of the electromagnetic spectrum.</p>	<p>Medical use of the electromagnetic spectrum</p> <ul style="list-style-type: none"> <li>• Use of ultraviolet as a sterilising agent</li> <li>• Use of Infrared to detect heat within the body.</li> </ul>

	<ul style="list-style-type: none"> <li>• Use of X rays for imagery (e.g. bones)</li> <li>• Use of gamma rays for imagery and treatment.</li> </ul>
6.1 Explain the use of ultrasonics in medical imaging and treatment.	<p>Ultrasonics are non-invasive and are high frequency sound waves</p> <p>Uses –</p> <ul style="list-style-type: none"> <li>• visualising anatomical structures in real time</li> <li>• detecting abnormalities;</li> <li>• monitoring pregnancy</li> <li>• endocardiography</li> <li>• treating soft tissue injuries and muscle strains</li> </ul>
6.2 Explain the use of magnetic resonance (MR) in medical investigations.	<ul style="list-style-type: none"> <li>• MR uses powerful magnetic fields.</li> <li>• The body is mainly water and fat and they hydrogen atoms (protons) align themselves to the magnetic field.</li> <li>• Radio waves are briefly emitted through the patient and this disrupts the alignment of the hydrogen.</li> <li>• After the burst the hydrogen atoms realign and release the additional energy form the radio waves.</li> <li>• This energy is analysed to build up a detailed image of the body.</li> </ul> <p>Uses include:</p> <ul style="list-style-type: none"> <li>• Diagnostic Imaging</li> <li>• Monitoring disease progression</li> <li>• Planning surgery</li> <li>• Medical research into the structure of the body and disease mechanisms.</li> </ul>

### Indicative content

The following content is to be included in the assessment of the unit.

Learning outcomes	Indicative content
1.1 Describe the fundamental differences between protons, neutrons and	The learner must describe the fundamental differences between protons, neutrons and electrons in terms of mass and charge using the following information.

<p>electrons in terms of mass and charge.</p>	<p>Proton – positive charge and mass of <math>1.673 \times 10^{-27}\text{Kg}</math>          Neutron – no change and mass of <math>1.674 \times 10^{-27}\text{Kg}</math>          Electron – negative charge and a mass of <math>9.1 \times 10^{-31}\text{Kg}</math></p>
<p>2.1 Explain how the range in air and penetrating powers of alpha, beta, gamma and x-rays are related to their nature and properties.</p>	<p>The learner must be able to explain how the range in air and penetrating powers of alpha, beta, gamma and x-rays are related to their nature and properties using the following information:</p> <ul style="list-style-type: none"> <li>• Alpha particle – large, slow moving in air, unable to penetrate deep due to relative size</li> <li>• Beta particle – fast moving electron, relatively strong penetrating power.</li> <li>• Gamma rays – no mass just energy, very fast moving in air and high penetrating power.</li> <li>• X rays are not as fast and have less penetrating power due to having lower energy.</li> </ul>
<p>2.2 Explain the safety procedures followed when using alpha, beta and gamma radiation and x-rays.</p>	<p>The learner must explain the safety procedures followed when using alpha, beta and gamma radiation and x-rays, to include the following with examples:</p> <ul style="list-style-type: none"> <li>• Use of PPE (e.g, gloves, protective eye wear and clothing)</li> <li>• Storage and disposal of PPE to avoid contamination.</li> <li>• Safety equipment – (e.g. handle with tongs, physical protection equipment such as shielding)</li> <li>• Exposure times to limit exposure the radioactive material</li> <li>• Storage using suitable shielded containers.</li> <li>• Risk assessment to ensure the above are all carried out and regular monitoring using logs.</li> </ul> <p>Learners must explain the variation of use for the different types of radioactive sources.</p>
<p>3.1 Explain the use of the Barium meal for soft body imaging.</p>	<p>The learner must explain the use of the Barium meal for soft body imaging, including the following stages of the procedure:</p> <ul style="list-style-type: none"> <li>• Ensure patients stomach is empty before procedure</li> <li>• Patient is given a liquid containing Barium. Barium shows up well on Xrays and it lines the digestive tract</li> <li>• Xrays are taken of the digestive tract which are used to check for abnormalities.</li> <li>• Afterwards to patient is told to drink lots of water to flush the Barium out</li> </ul> <p>Examples of patient’s cases could be provided for the learner to refer to when explaining the use.</p>

<p>3.2 Explain the use of <math>\gamma</math>-rays in imaging.</p>	<p>The learner must demonstrate that they have an understanding of the following procedures and when they would be used most effectively.</p> <p>Procedure for Positron Emission Topography (PET)</p> <ul style="list-style-type: none"> <li>• Small amount of radioactive substance (called a radiotracer) is injected into the patient.</li> <li>• Common radiotracers are fluorine-18, Oxygen-15 or Carbon-11)</li> <li>• The radiotracer emits positrons which collide with electrons in the body, releasing 2 gamma rays).</li> <li>• Detectors outside the body build up an picture – often used for metabolic functions or cancer cell activity</li> </ul> <p>Procedure for Single-Photon Emission Computed Tomography (SPECT)</p> <ul style="list-style-type: none"> <li>• Small amount of radioactive substance (called a radiotracer) is injected into the patient.</li> <li>• Common radiotracer is Technecium-99m</li> <li>• The radiotracer emits gamma rays</li> <li>• Detectors outside the body build up an picture – often used for imaging organs and tissues (e.g. heart, brain, bones, thyroid)</li> </ul>
<p>3.3 Explain the use of internal sources of radiation in treatment procedures.</p>	<p>The learner must demonstrate that they can explain the use of internal sources of radiation in treatment procedures (called Brachytherapy) to include:</p> <ul style="list-style-type: none"> <li>• Placement of radioactive source close to or within a tumour to target cells or tissue to be destroyed.</li> <li>• Targeted and high dose concentrations to avoid destroying healthy tissue and cells.</li> <li>• Reducing side effects c.f. external radiation treatment.</li> <li>• Use of targeted sources means that high doses can be administered.</li> </ul>
<p>4.1 Explain how technetium-99m is generated.</p>	<p>The learner must be able to explain how Technicium-99 is generated, to include the following:</p> <ul style="list-style-type: none"> <li>• Formed from Molybdenum-99 which is a byproduct from a nuclear reactor (e.g. formed as part of the decay series when enriched Uranium -235 is bombarded with neutrons).</li> <li>• Molybdenum-99 has a short half-life and decays to Technecium-99 via beta decay.</li> <li>• How it is then extracted and purified for medical use.</li> </ul>

<p>4.2 Explain the use of Iodine-131 in thyroid investigations.</p>	<p>The learner must be able to explain the use of Iodine -131 in thyroids investigations, to include:</p> <ul style="list-style-type: none"> <li>• Iodine-131 emitting both beta and gamma particles.</li> <li>• The beta particles destroying target treatment.</li> <li>• The gamma particles are used to generate imagery using external detectors.</li> <li>• The thyroid concentrates the iodine within it from the bloodstream thereby absorbing the iodine and avoiding other parts of the body being contaminated.</li> <li>• Iodine-131 is administered orally for the treatment of thyroid conditions such as thyroid cancer and hyperthyroidism.</li> </ul>
<p>5.1 Explain medical uses of parts of the electromagnetic spectrum.</p>	<p>The learner must be able to explain medical uses of parts of the electromagnetic spectrum, to include:</p> <ul style="list-style-type: none"> <li>• Use of radio waves in MRI scans</li> <li>• Use of ultraviolet as a sterilising agent</li> <li>• Use of Infrared to detect heat within the body</li> <li>• Use of X rays for imagery (e.g. bones)</li> <li>• Use of gamma rays for imagery and treatment.</li> </ul>
<p>6.1 Explain the use of ultrasonics in medical imaging and treatment.</p>	<p>The learner must be able to explain the use of ultrasonics in medical imagery and treatment, to include:</p> <ul style="list-style-type: none"> <li>• visualising anatomical structures in real time (such as organs)</li> <li>• detecting abnormalities such as fluid build-up, tumours and cysts, gall and kidney stones etc)</li> <li>• monitoring pregnancy and gynaecologic imaging</li> <li>• endocardiography to monitor the heart.</li> <li>• treating soft tissue injuries and muscle strains to promote tissue healing and pain relief.</li> </ul>
<p>6.2 Explain the use of magnetic resonance (MR) in medical investigations.</p>	<p>The learner must be able to explain the use of Magnetic Resonance in medical investigations, including:</p> <ul style="list-style-type: none"> <li>• MR uses powerful magnetic fields.</li> <li>• The body is mainly water and fat and they hydrogen atoms (protons) align themselves to the magnetic field.</li> <li>• Radio waves are briefly emitted through the patient and this disrupts the alignment of the hydrogen.</li> <li>• After the burst the hydrogen atoms realign and release the additional energy form the radio waves.</li> <li>• This energy is analysed to build up a detailed image of the body</li> </ul> <p>Uses should include:</p>

	<ul style="list-style-type: none"><li>• Diagnostic Imaging</li><li>• Monitoring disease progression</li><li>• Planning surgery</li><li>• Medical research into the structure of the body and disease mechanisms.</li></ul>
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### Assessment methodology

The following assessment methods are suggested for the assessment of this unit.

- Presentation
- Report
- Test