Unit 22: Medical Physics Applications

Delivery guidance

Learners may bring knowledge of medical physics applications through their own experiences or from knowledge of friends or family experiences.

You could give initial introductory input for your learners about radioactive sources, radioactive isotopes, radioactivity, X-rays and the electromagnetic spectrum and radioactive decay, which they may have covered in their previous studies.

Learners should be encouraged to research and learn about the uses of medical physics applications through articles in the various types of media about new techniques, new discoveries and through the National Health Service and other health services.

A number of universities and medical science industries welcome learners that have a good knowledge and understanding medical physics applications.

To complete this unit your learners will need access to the internet, CD-ROMs, journals or magazines, and books.

The delivery methods proposed for this unit are, for example:

- discussions – class and small group discussions on case studies and new techniques/discoveries and applications
- visits to radiography departments
- visiting/guest speakers from radiography departments or from health and safety organisations
- tutor presentation/guidance – briefing and monitoring learners about individual research and valid appropriate websites and references
- group and individual learner activity – where learners can research relevant materials and case studies
- video and YouTube clips – where learners can learn and reinforce their knowledge and understanding of underlying physics concepts and through demonstrations of various medical physics techniques in a medical health scenario.

Approaching the unit

For **learning aim A**, introduce the unit by informing the learners about the sections in the unit, how it fits within the qualification and how it relates to other units. Inform the learners about the assignments that they need to complete.
Give some input on different types of non-ionising instrumentation radiation techniques and then discuss with the learners any previous experiences they have had to engage and motivate them. You could follow this with a general discussion on how each of the techniques relates to screening, diagnosis, and treatment of patients, and the benefits, advantages and disadvantages of each of the techniques.

You could invite a guest speaker to inspire learners about non-ionising instrumentation radiation techniques. It is important for learners on an applied science programme of study to understand the fundamental physics concepts that enable the different techniques to function reliably and effectively for screening, diagnosis and treatment of patients.

Give an initial input with regard to fundamental physics of magnetic resonance imaging, covering an outline of the instrumentation used to scan for protons in different environments within the body. Learners will need to understand the underlying theory of energising hydrogen nuclei (high-energy state) when they absorb a certain radio frequency pulse input which resonates with the strength of the magnetic field and the relaxation of the hydrogen nuclei (low-energy state) to emit a radiofrequency signal output pulse. This can be captured by a powerful computer and produce high-resolution images of soft tissues in the body. You could ask learners, in small groups or individually, to investigate magnetic resonance imaging and its application in the health service. You could repeat the delivery method above for the other three non-ionising instrumentation radiation techniques shown in the content.

For **learning aim B**, give some input on different types of ionising instrumentation radiation techniques and then discuss with the learners any previous experiences they have had to engage and motivate them. This could include some of the latest current media articles on 'Proton Beam Therapy' or 'Gamma Knife Surgery'. Follow this by having a general discussion on how each of the techniques relates to screening, diagnosis and treatment of patients, and the benefits, advantages, disadvantages of each of the techniques.

A guest speaker from the local hospital could be asked in to inspire learners about ionising instrumentation radiation techniques. It is important for learners on an applied science programme of study to understand the fundamental physics concepts that enable the different techniques to function reliably and effectively for screening such as use of mammograms for screening purposes, diagnosis and treatment of patients.

Give an initial input with regard to fundamental physics of X-rays covering an outline of the instrumentation used, where the X-rays are generated in a vacuum tube by producing high-energy electrons from a metal cathode which accelerate to a positively charged tungsten anode. The resulting X-rays are directed to pass through the patient's body on to a photographic plate or digital recorder to produce an image. You could also cover how the X-ray intensity and penetration is increased.

You could ask learners, in small groups or individually, to investigate X-rays and their application in the health service. You could repeat this delivery method for the other three ionising instrumentation radiation techniques shown in the content.

For **learning aim C**, introduce the topic by enabling learners to share any stories they have about ionising radiation techniques. Give input for your learners about health and safety, associated risks and side effects with reference to both patients and operators, and include legislative requirements. Discuss the subject of patient choice and consent when considering the use of radiation therapy/techniques. Learners could compare a number of well-known cases. In small groups or as individuals your learners could then carry out an investigation through various media sources such as journals, media sources, magazines, leaflets, the internet and books about health and safety precautions, risks to patients and operators with reference to the use of ionising radiation for screening, diagnosis and treatment. A guest speaker from the local Health and Safety authority or from a radiography department in a hospital could help learners understand the importance of health and safety when using ionising radiation sources and instrumentation. You could then repeat the delivery method above for the other three non-ionising instrumentation radiation techniques.

Assessment Model

Learning aim	Key content areas	Recommended assessment approach
A Explore the principles, production, uses and benefits of non-ionising instrumentation techniques in medical applications	**A1** Magnetic resonance imaging (MRI) **A2** Lasers **A3** Infrared thermography (IRT) **A4** Ultrasound	A research report showing the different types of non- ionising and ionising radiation techniques. Learners could produce visual presentations for the underlying principles and production. They could produce tables and use case studies for comparisons in justifying techniques used for diagnosis and treatment.
B Explore the principles, production, uses and benefits of ionising instrumentation techniques in medical applications	**B1** X-rays **B2** Computer tomography (CT) or Computerised axial tomography (CAT) **B3** Gamma ray Imaging **B4** Radiotherapy, Gamma Knife surgery and proton beam therapy	
C Understand health and safety, associated risks, side effects and limitations of ionising and non-ionising instrumentation techniques in medical applications	**C1** Safety precautions, side effects and risks for operators and patients of ionising radiation **C2** Safety precautions, side effects and risks for operators and patients of non-ionising radiation	A report showing the health and safety and risk implications for operators and patients with the use of case studies, reference to legislative requirements and associated articles. Information from visits or visiting speakers.

Assessment guidance

This unit is internally assessed by a number of internally set assignments. Each assignment should cover at least one complete learning aim. It is essential that a learning aim is assessed as a whole and not split into tasks or sub-tasks per criterion.

There are two suggested summative assignments for this unit as shown in the table above, each covering one or two learning aims. All learners must independently generate individual evidence that can be authenticated; this also applies to learners who have completed their assignments in a group.

Learners should incorporate research that is corroborated by a referenced bibliography. Learners need to produce their assignment reports in a style that allows assessors to assess the evidence presented for each individual criterion and to ensure that three learning aims have been achieved. Learners could produce evidence using diagrams, tables, presentations, technical scientific posters or leaflets.

Getting started

This provides you with a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 22: Medical Physics Applications

Introduction

Introduce the unit, learning aims and assessment criteria. You could then brief the learners how the unit fits within the qualification and relates to other units.

Revise some underlying relevant concepts about radioactivity, radioactive decay and the electromagnetic spectrum that learners should have covered previously.

Learning aim A – Explore the principles, production, uses and benefits of non-ionising instrumentation techniques in medical applications

- Brief learners about non-ionising instrumentation techniques and then have a discussion where learners can contribute and share experiences of the techniques used for screening, diagnosis or treatment. You could also use case studies of patients and the consideration of patient choice and consent.
- Invite a guest speaker to come in and discuss non-ionising radiation, its importance in medical applications and any new developments taking place or being available in the future.
- Give a presentation to learners about the fundamental physics concepts underlying magnetic resonance imaging, covering the instrumentation, the process of nuclear magnetic resonance and the production of high-resolution images.
- Brief learners about carrying out an investigation into magnetic resonance imaging, and give guidance about reliable and valid sources of information. Ask learners to carry out an investigation into magnetic resonance imaging.
- Use the same sequence as above to deliver magnetic resonance imaging, to cover instrumentation, the underlying physics concepts and uses of lasers, infrared thermography and ultrasound and where applicable the types of images produced.
- Ensure learners carry out research into lasers, infrared thermography and ultrasound.
- Discuss with the learners the different medical applications of non-ionising radiation for screening, diagnosis and treatment purposes. Discuss which technique would be a suitable choice for different medical conditions.

Learning aim B – Explore the principles, production, uses and benefits of ionising instrumentation techniques in medical applications

- Brief learners about ionising instrumentation techniques and then have a discussion where learners can contribute and share experiences of the techniques used for screening, diagnosis or treatment. You could also use case studies of patients and the consideration of patient choice and consent.
- Invite a guest speaker to come in and discuss ionising radiation, its importance in medical applications and any new developments taking place or being available in the future.
- Give a presentation to learners about the fundamental physics concepts underlying X-rays,

covering the instrumentation, the process of producing X-rays and the production of images.

- Brief learners about carrying out an investigation into X-rays, and give guidance about reliable and valid sources of information. Enable learners to carry out research into X-rays in preparation.
- Use the same sequence as above to deliver X-rays, to cover computerised tomography, gamma ray imaging and radiotherapy techniques for instrumentation, the underlying physics concepts and uses of them and where applicable the types of images produced.
- Discuss with the learners the different medical applications of ionising radiation for screening, diagnosis and treatment purposes. Discuss which technique would be a suitable choice for different medical conditions.
- Ask learners to comment on a number of different medical conditions and the type of non-ionising or ionising radiation they would select for that condition in terms of advantages, disadvantages and side effects.

Learning aim C – Understand health and safety, associated risks, side effects and limitations of ionising and non-ionising instrumentation techniques in medical applications

- Brief and discuss with learners the need for health and safety for both operators and patients when using ionising instrumentation techniques during screening, diagnosing and treatment. Learners could be encouraged to share their experiences and from members of their family and friends.
- Learners could also read and discuss a number of well-known health and safety case studies with regard to ionising radiation that you have given.
- Invite a guest speaker from a local hospital or from the Health and Safety Executive to talk about health and safety, side effects and associated risks with ionising and non-ionising radiation and health and safety legislation.
- Enable learners to investigate ionising radiation and health and safety issues.
- Brief and discuss with learners the measures in place for health and safety for both operators and patients when using non-ionising instrumentation techniques during screening, diagnosing and treatment. Learners could be encouraged to share their experiences and/or from members of their family and friends.
- Learners could also read and discuss a number of well-known health and safety case studies with regard to non-ionising radiation that you have given.
- Ask learners to investigate non-ionising radiation and health and safety issues.
- Discuss with learners the implications of unsatisfactory health and safety measures to patients and operators.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- *Unit 3: Principles and Applications of Physics I*
- *Unit 7: Principles and Application of Physics II.*

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International qualification in Applied Science. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Foal, S., Hocking, S., Llewellyn, R., Musa, I., Patrick, E., Rhodes, P. and Sorensen, J., *BTEC Level 3 Applied Science Student Book*, Pearson, 2010 (ISBN: 978-1846706800).
This book contains Unit 20 Medical Physics Techniques material for the 2010 specification.

Journals

Nature
An international journal covering research spanning all areas of science.

New Scientist
Covering the latest news and articles about science and technology.

Scientific American
Latest science stories, articles and news.

Physics World
Institute of Physics – latest news about physics articles and stories.

Videos

www.youtube.com/watch?v=0-ewpwwcxK0 CT scan: what happens.

www.youtube.com/watch?v=9GsrIARpTms Medical physics gamma imaging.

www.youtube.com/watch?v=tVNHZKxK0Us Medical thermography training.

www.youtube.com/watch?v=AwXJNXNcLNs MRI scan: what happens?

www.youtube.com/watch?v=C23cRCZ2J98 Production of lasers.

www.youtube.com/watch?v=kpJBfN4WOng Ultrasound tutorial video.

www.youtube.com/watch?v=wbbsbE2mQuA X-rays work.

Websites

www.ase.org.uk
Association for Science Education – science resources for tutors, journals, textbooks, useful links.

www.iop.org
Institute of Physics – background information on medical physics resources.

www.nationalstemcentre.org.uk/elibrary/collection/565/teaching-medical-physics National STEM centre – Teaching Medical Physics.

www.nhs.uk/conditions/ct-scan/pages/introduction.aspx CT Scans from NHS Choices.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.