Institute of Physics and Engineering in Medicine

Masters Level Accreditation Framework (MLAF)

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1 IPEM Masters Accreditation

1 – IPEM Masters Accreditation

IPEM Accreditation of degree programmes gives higher education institutions and prospective students confidence that courses meet the expected quality and learning outcomes required for a career in medical physics/clinical engineering. Accreditation supports clinical scientists in their practice through the provision and assessment of education and training. Accreditation supports IPEM's dedication to developing the next generation of medical physicists and clinical engineers. This accreditation scheme aims to ensure that graduates of accredited programmes are equipped with the knowledge and skills for the medical physics or clinical engineering workplace, be that in industry, healthcare, or academic environments. Accreditation gives confidence that the course meets strict suitability and quality criteria for providing education in this field.[1]

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IPEM's Mission:

Improving health through Physics and Engineering in Medicine.

IPEM's Vision:

Developing the professional, improving healthcare, transforming lives together.

IPEM's Values:

Trusted
The leading voice in improving health through physics and engineering.

Inclusive
Enabling a diverse and inclusive professional community.

Progressive
Delivering innovative practice development for the public good.

Benefits to having an accredited degree programme include:

- Accreditation is recognised as a high-quality seal of approval throughout industry and academia internationally.
- Accredited programmes can display the Certificate of Accreditation and may use the IPEM accredited logo on promotional material and documentation.

IPEM | Masters Level Programme Accredited

- Accredited programmes are included in the accredited programmes list.
- Accreditation supports the training of clinical scientists in both medical physics and clinical engineering.
- Where possible, the training team connect graduates with employers and appropriate career and networking opportunities.
- The IPEM Student Prize awarded for the best student project.

The overall MLAF structure, for both physics and engineering streams, is shown on page 8 (Figure 1).

2 Framework Description

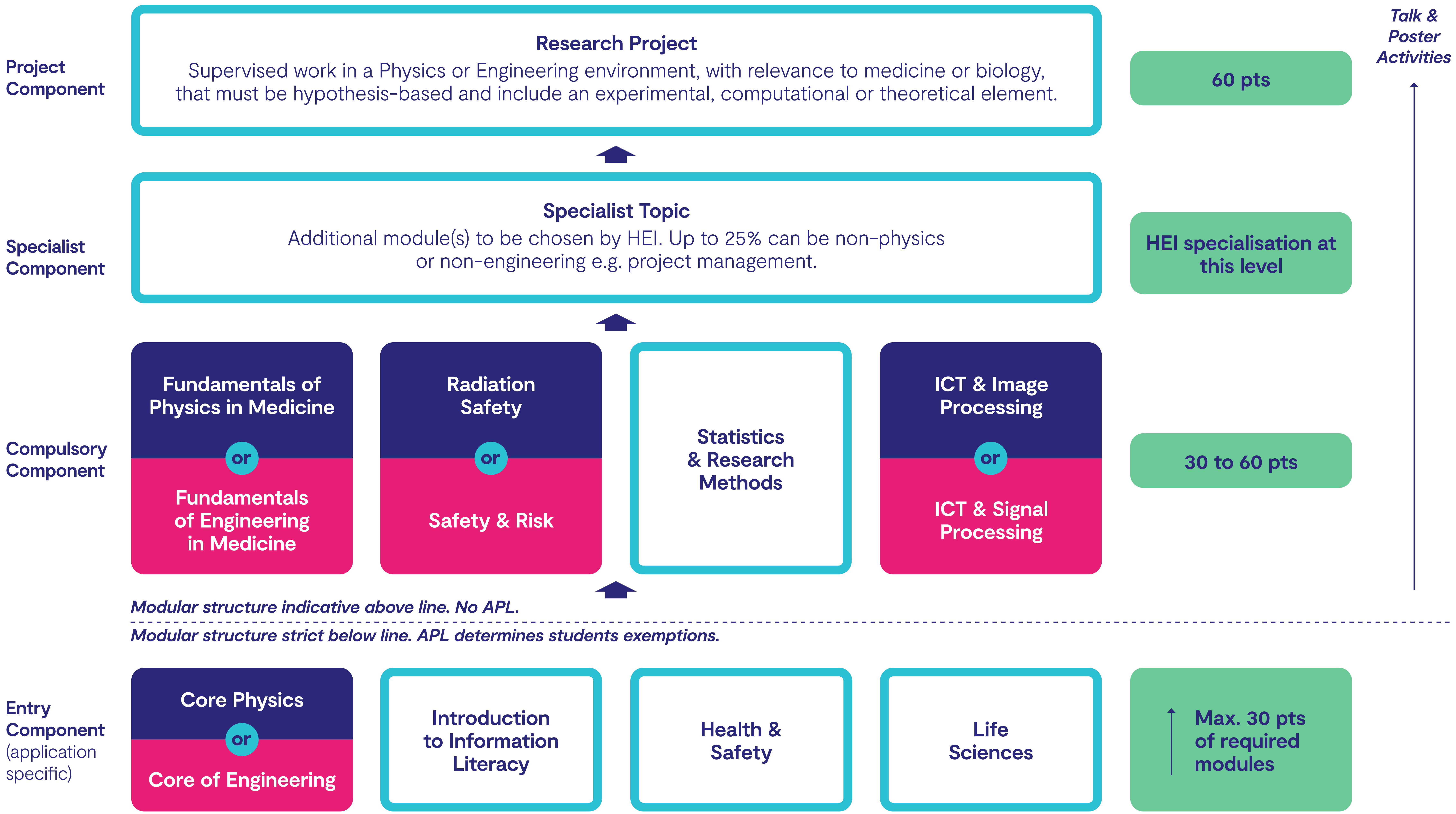
Abbreviations:

ICT: Information & Communications Technology
APL: Accredited Prior Learning
HEI: Higher Education Institute
pts: ‘UK academic’ points or credit accumulation and Transfer Scheme point (CATS) where 30UK = 15ECTS under the Bologna process
Max.: Maximum

Figure 1

Accredited Masters Award (for either Physics or Engineering Stream)

Award ≥ 180pts



2 – Framework Description

The framework (Figure 1) divides the required learning outcomes into two streams: Engineering or Physics. Normally, HEIs apply for programme accreditation against the learning outcomes of one stream, however, if an HEI can deliver a demonstrably broad curriculum, the option to comply with both streams does exist. The framework utilises the UK Credit Accumulation and Transfer Scheme (CATS) point, equal to approximately 10 hours of student study time. One UK credit point is equivalent to half a European (ECTS) point. Thus a masters degree is equal to 180 CATS points or 90 ECTS points.

The framework has four components three of which exist above the 'broken line' in Figure 1. The 'broken line' defines the boundary between undergraduate and postgraduate subject level description. As normal in UK Masters degrees, students must accumulate 180 credit points, of which 150 points must be at Framework for Higher Education Qualifications (FHEQ)[2] Level 7 (above the line). Students may only attain 30 credit points at FHEQ Level 6 (below the line).

Whilst the framework is explained in terms of indicative 'subject area' components, there is no obligation for HEIs to deliver content within modules that directly map to these subject areas. IPEM only requires that HEIs demonstrate that students on their programme(s) achieve the learning outcomes for the relevant stream (physics or engineering). All learning outcomes must be met by all possible curriculum choices within each programme being accredited.

To foster communication skills, IPEM requires that both a talk and poster activity must be completed within the curriculum, not necessarily in the same module, and at least one of them must be assessed summatively. Finally, IPEM stipulates that condonement[†] is not permitted, and that up to 20 credits, excluding major individual and group project work, may be compensated[††], within MLAF-accredited programmes.

[†] Condonement is defined here as *the practice of allowing students to fail and not receive credit for one or more modules within a degree programme, yet still qualify for the award of the degree.*

[††] Compensation is defined here as *the practice of allowing marginal failures, of not more than 10% below the nominal pass mark, of one or more modules and awarding credit for them, on the basis of good overall academic performance (as defined by an HEI).*

2.1 – The Entry Level Component

The Entry Level Component are shown in Figure 1 below the ‘broken line’. Entry level learning outcomes are delivered at a minimum of FHEQ Level 6 and individual students may only transfer up to 30 points of FHEQ Level 6 learning to their masters award. HEI’s may deliver this learning at FHEQ level 7. HEIs are free to name these entry modules as they see fit, and to merge them if desired. There is no minimum points allocation for each component area, provided points are consistent with what is needed to deliver the material to cover learning outcomes.

This is an applicant-specific component of the framework enabling completion of an accredited programme by students with differing, but appropriate, educational backgrounds. On entry, the Programme Director may waive one or more ‘entry component’ modules for individuals with demonstrated recognised/accredited prior learning covering all learning outcomes of each waived module.

Supported by IPEM, an annual audit process will monitor the decisions of the Programme Director, to ensure consistency across all IPEM’s MLAF-accredited programmes. See Appendix A for common examples of justifications for waiving entry component modules. As students must accumulate 180 credit points to graduate, any waived components would necessitate additional academic credit to be taken from elsewhere in the curriculum, most likely from the specialist components.

2.2 – The Compulsory Component

The Compulsory Component contains learning outcomes considered by IPEM to be essential for being a physicist or engineer working in medicine or biology. These are outlined within four ‘subject areas’: a ‘Fundamentals’ subject area for core physics or engineering in medicine, a ‘Safety/Risk’ subject area, an ‘ICT with image/signal processing’ subject area and one common ‘subject area’ for both streams: ‘Statistics and Research Methods’. There is no fixed UK points allocation for the ‘compulsory component’ of the framework, with between 30 and 60 UK points acceptable.

2.3 – The Specialist Component

The Specialist Component is intentionally designed without prescribed learning outcomes to encourage Higher Education institutional diversification across medical physics and biomedical engineering. HEIs may design their own FHEQ Level 7 learning outcomes, complying with Blooms/SOLO taxonomy[3] in their development. This enables institutes to focus on their strengths and assists them in designing and adapting their programmes to suit the needs of their students. Up to 25% of points awarded at the 'specialist component' level may be dedicated to suitable non-physics or non-engineering topics that develop workplace or innovation skills. Examples would include module titles such as 'Project management', 'Innovation in medical technology' or 'Medical device safety and design'. Specialist modules provide HEIs the opportunity to diversify the title(s) of their MLAF-accredited degree(s), offering for example: 'Radiation physics with proton therapy', 'Biomedical and optical engineering' or 'Medical Imaging with instrumentation'.

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2.4 – The Research Project Component

The research project component is required to consist of at least 60 UK CATS points. The project need not cover original research material, but must show evidence of the student's own work and self-direction, and have appropriate and qualified supervision. Normally, the project should be hypothesis-driven work that includes a data analysis aspect arising from experimental and/or computational elements, as well as a relevant literature review. Whilst the research project component must be passed, HEIs may award degree classifications (e.g. pass, merit, distinction) according to its institutional policies.

3 Programme-wide Learning Outcomes (FHEQ Level 7)

3 – Programme-wide Learning Outcomes (FHEQ Level 7)

On completion of the degree, the student must be able to:

A1. Apply fundamental laws and principles of physics and/ or engineering to medical applications, some of which are at, or are informed by, the forefront of the discipline.

A2. Formulate strategies to solve complex problems in physics or engineering using a variety of experimental, analytical, design, statistical, mathematical and/or computational techniques.

A3. Relate the underlying principles of specialised medical equipment to its routine operation and its common quality assurance procedures.

A4. Demonstrate an awareness of safety principles, risk management and legislative requirements governing best practice in areas of medical physics or biomedical engineering.

A5. Apply a range of ICT skills to relevant scientific tasks in medical physics or biomedical engineering, such as the use or design of image processing software, treatment planning systems and medical equipment management systems.

A6. Manage, from initial planning stage to final dissemination of results, an experiment or investigation (requiring a literature review) in a field of medical physics or biomedical engineering.

A7. Demonstrate a critical awareness of the role of medical physics and/or biomedical engineering in medicine considering the technological, social and ethical aspects of the field and its development.

3 – Programme-wide Learning Outcomes (FHEQ Level 7)

A8. Communicate scientific concepts to an audience of his/her peers in a concise, accurate and informative manner, leading to the presentation of logical conclusions at a level appropriate to the audience.

A9. Manage his/her own learning and make selective use of a variety of resources including appropriate texts, research articles and other primary sources in his/her work.

A10. Critically evaluate experimental findings against previous measurement or the scientific literature, in terms of statistical significance and research methodology.

4 Entry Component Learning Outcomes (FHEQ Level 6)

Adapted from the current QAA subject benchmark statements (2014)[1]

4.1 – Health & Safety Learning Outcomes

The applicant to the masters programme must be able to (both streams):

B1. Demonstrate knowledge of the principles underpinning appropriate national and international health and safety legislation (e.g. UK and/or EU regulations).

B2. Identify hazards in a given clinical or workplace environment through risk assessment, leading to considered advice on best practice.

B3. Describe risks and legislative requirements concerning a range of workplace hazards including non-ionising radiation, ionising radiation, electrical systems, mechanical systems and chemicals in the clinical or workplace environment.

We envisage that few masters applicants will have covered all these outcomes, the exception being those who can present evidence of health and safety training via workplace or CPD training records for all learning outcomes within the previous five years.

4.2 – Life Sciences Learning Outcomes

The applicant to the masters programme must be able to (both streams):

C1. Demonstrate an understanding of the principles of biological organisation, including the structure and function of cells and tissues as well as cell division and growth.

C2. Describe the structure and function of the major organ systems of the human body and the physiological basis of human reproduction.

C3. Apply knowledge of the terminology and nomenclature of anatomical positioning to clinical scenarios.

C4. Apply appropriate anatomical and physiological knowledge to relevant clinical situations where physics and engineering are used in medicine.

It is envisaged that an applicant with an honours degree in medicine or some appropriate life science subjects will have covered all these outcomes, as may other healthcare graduates, depending on course syllabus and work experience.

4.3 – Introduction to Information Literacy Learning Outcomes

The applicant to the masters programme must be able to (both streams):

D1. Demonstrate a critical awareness of the advantages and disadvantages of different types of literature used by scientists and engineers in medicine, such as peer-reviewed journals, professional body guidance and manufacturer technical notes.

D2. Explain the strengths and weaknesses associated with selected information gathering and dissemination methodologies.

D3. Demonstrate effective use of appropriate ICT packages or systems for the analysis and retrieval of information, such as spreadsheets and literature searching software.

D4. Communicate scientific or engineering information with good standards of academic integrity through original, clear and accurate means.

D5. Generate an accurate and selective list of references to support an original output.

It is envisaged that an applicant with evidence of completing an individual extended piece of scientific writing in English will have covered all these outcomes. This should normally be a report of at least 3000 words, a dissertation or equivalent output, completed for academic assessment or scrutiny in the last 5 years (i.e. PhD thesis, MSc thesis, undergraduate honours project).

4.4 – Core Physical Sciences Learning Outcomes

The applicant to the masters programme must be able to (physics stream):

E1. Formulate and tackle problems, both mathematical and conceptual, involving physical laws and principles, specifically in mechanics, atomic and nuclear structure, dynamics and electromagnetism.

E2. Apply relevant physical principles and laws when tackling scientific problems and scenarios.

E3. Demonstrate investigative skills commonly associated with research project work: these may include analysing experimental results or theoretical work or computational work or practical investigation.

E4. Apply developed mathematical skills in numerical manipulation and in the presentation and interpretation of information.

E5. Demonstrate a working knowledge of relevant mathematical concepts to physics and numerical modelling, including calculus, indices, exponentials and logarithms.

E6. Demonstrate a comprehensive working knowledge of the SI system of units, conventions for unit prefixes and symbols, and their conversion to other commonly-used units in physics.

It is envisaged that an applicant with an honours degree in physics will have covered all these outcomes for the relevant stream.

4.5 – Core Engineering Learning Outcomes

The applicant to the masters programme must be able to (engineering stream):

F1. Formulate and tackle problems, both mathematical and conceptual, involving physical/engineering laws and principles, specifically in electrical, electronic, mechanics and electromagnetism.

F2. Apply relevant physical and/or engineering principles and laws when tackling problems

F3. Acknowledge special and limiting cases and the assumptions or approximations made at the outset of an engineering problem.

F4. Demonstrate investigative skills commonly associated with research project work: these may include analysing results or theoretical work or engineering design or computational/practical investigation

F5. Apply developed mathematical skills in numerical manipulation and in the presentation and interpretation of information.

F6. Demonstrate a working knowledge of relevant mathematical concepts to engineering and numerical modelling, including calculus, indices, exponentials and logarithms.

F7. Demonstrate a comprehensive working knowledge of the SI system of units, conventions for unit prefixes and symbols, and their conversion to other commonly-used units in engineering.

It is envisaged that an applicant with an honours degree in engineering will have covered all these outcomes for the relevant stream.

5 Compulsory Component Learning Outcomes (FHEQ Level 7)

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5.1 – Fundamentals of Physics in Medicine Learning Outcomes

These 'subject area' learning outcomes are mapped to the 'programme-wide' learning outcomes, labelled i.e. [A1] or [A4].

The student must be able to (physics stream):

G1. Explain the principles of X-ray production, including the origins and nature of the X-ray spectrum, in relation to technologies used clinically to treat and diagnose patients. **[A3]**

G2. Compare the use, generation and handling of radioactive isotopes in different medical applications of imaging and therapy. **[A1]**

G3. Evaluate the significance of the main interaction mechanisms of X and γ radiation with human tissue and other clinically-relevant materials for a range of imaging and therapy applications: elastic scatter, Compton scatter, photo-electric absorption and pair production. **[A1]**

G4. Relate fundamental physics concepts to the operating principles of imaging technologies involving ionising radiation, including X-ray, CT, and nuclear medicine. **[A1]**

G5. Relate fundamental physics concepts to the operating principles of imaging technologies involving non-ionising radiation, including MRI and ultrasound. **[A1]**

5.1 – Fundamentals of Physics in Medicine Learning Outcomes

G6. Explain the scientific principles of established techniques for quality assurance, dosimetry and image optimisation in medical imaging using appropriate concepts and calculations. **[A2, A3]**

G7. Relate fundamental physics concepts to the operating principles of the main ionising radiation treatment technologies used in medicine, including: external beam radiotherapy (kilovoltage, megavoltage and particle), brachytherapy and unsealed source therapy. **[A1]**

G8. Explain the scientific underpinnings of established techniques for dosimetry and treatment planning in radiotherapy using appropriate concepts and calculations. **[A2, A3]**

G9. Briefly outline the scientific principles used in optical and/or ultra-violet radiation techniques (including lasers) in medicine, using appropriate concepts and calculations. **[A2, A3]**

G10. Appraise new developments and innovation in existing and emerging fields of medical physics and their potential impact on current diagnosis and treatment. **[A1, A3, A7, A10]**

5.2 – Fundamentals of Engineering in Medicine Learning Outcomes

The student must be able to (engineering stream):

H1. Employ a sound theoretical approach when applying engineering principles to aid monitoring, diagnosis, treatment or measurement of human anatomy or physiology. **[A1]**

H2. Appraise constraints and opportunities for the development and transfer of engineering technology within medicine and biology. **[A3, A7]**

H3. Solve theoretical and practical problems in medical and biological engineering, in fields such as medical instrumentation, medical electronics and assistive technology. **[A2]**

H4. Compare design solutions to common medical and biological engineering problems leading to an evaluation of their effectiveness. **[A2]**

H5. Discuss the role of medical and biological engineering in innovation and healthcare, for fields such as biomaterials and tissue engineering, physiological and functional assessment and rehabilitation engineering. **[A7, A10]**

H6. Appraise new developments in existing and emerging fields of medical and biological engineering and their potential impact on healthcare. **[A7, A10]**

5.3 – Radiation Safety Learning Outcomes

The student must be able to (physics stream):

J1. Describe key radiobiological concepts of ionising radiation, such as stochastic, deterministic, cellular and genetic effects. **[A4]**

J2. Assess the risks to patients and staff from radiation exposure using appropriate measures of dose used in radiation protection, such as absorbed dose and kerma. **[A4]**

J3. Assess the precautions necessary to reduce risks to staff and patients such as those arising from the use of medical devices and procedures (e.g. those associated with clinical magnetic resonance systems). **[A4]**

J4. Briefly discuss the mechanisms and level of potential damage from non-ionising radiation exposure (UV, infra-red and laser, ultrasound) in typical clinical and workplace environments. **[A4]**

J5. Formulate strategies to comply with relevant legislation relating to the use of ionising radiation, non-ionising radiation and high magnetic fields for diagnosis and treatment. **[A4]**

5.4 – Safety and Risk Learning Outcomes

The student must be able to (engineering stream):

K1. Demonstrate an understanding of key safety concepts, such as electrical, mechanical, biological, radiobiological and chemical hazards and their effects. **[A4]**

K2. Evaluate risk to patients, staff and others from workplace and other hazards using appropriate risk assessment and risk management techniques. **[A4]**

K3. Assess the precautions necessary to reduce risks to staff, patients and others such as those arising from the design, construction, management and use of medical or laboratory devices, systems and procedures. **[A4]**

K4. Perform risk-benefit analyses for clinical and workplace safety scenarios. **[A4]**

K5. Describe relevant legislation, standards and governance frameworks such as those relating to the use of medical or laboratory devices, implants, electrical equipment, ionising radiation and non-ionising radiation for diagnosis and treatment. **[A4]**

5.5 – Statistics & Research Methods Learning Outcomes

The student must be able to (both streams):

L1. Perform common statistical tests on datasets, using software packages or statistical tables, such as confidence intervals and comparisons of means (e.g. t-test and ANOVA). **[A10]**

L2. Evaluate the outcome of test results in medical physics or biomedical engineering experiments in terms of their statistical significance. **[A10]**

L3. Communicate findings for non-specialist audiences using simple concepts such as probability or odds. **[A8]**

L4. Critically evaluate the research design and methodologies used in scientific literature in the field of physics and/or engineering in medicine. **[A10]**

L5. Compare the effectiveness of clinical trial designs in medical physics and bioengineering, such as double-blind, randomised, matched and retrospective designs. **[A10]**

5.6 – ICT and Image Processing Learning Outcomes

The student must be able to (physics stream):

M1. Appraise security and legislative considerations relating to the electronic storage and transfer of clinical data such as images and patient records. **[A7]**

M2. Demonstrate the ability to use software tools such as spreadsheets, databases, referencing software and programming/modelling packages competently. **[A5]**

M3. Relate the concepts of spatial, temporal, and contrast resolution in medical imaging to outcomes for clinical reporting and patient dose delivery. **[A3]**

M4. Analyse parameters that determine the nature and quality of a digital image such as sampling theory, acquisition rates, and image display quality. [**A3]**

M5. Evaluate outcomes of common manipulation techniques on medical images such as compression, translation, rotation, scaling, Fourier transform, averaging and noise reduction. **[A10]**

M6. Describe the principles underpinning image registration, segmentation and fusion as applied to multi-modality imaging and image guided procedures. **[A3]**

5.7 – ICT and Signal Process Learning Outcomes

The student must be able to (engineering stream):

N1. Appraise security and legislative considerations relating to the electronic storage and transfer of clinical data such as images and patient records. **[A7]**

N2. Demonstrate the ability to use software tools such as spreadsheets, databases, referencing software and programming/modelling packages competently. **[A3]**

N3. Analyse parameters that determine the nature and quality of medical signals and images such as sampling theory, acquisition rates, resolution, signal and image display quality. **[A3]**

N4. Evaluate outcomes of common manipulation techniques on medical signals and images such as filtering, compression, translation, rotation, scaling, Fourier transform, averaging and noise reduction. **[A10]**

N5. Apply the principles underpinning the acquisition and processing of physiological signals and images to theoretical problems. **[A1, A2]**

6 Specialist Component Learning Outcomes (FHEQ Level 7)

6 – Specialist Component Learning Outcomes (FHEQ Level 7)

To be submitted by individual HEI programme directors for each specialist module.

These learning outcomes are written by each HEI and will be scrutinised in detail during accreditation assessments.

Up to 25% of the component points may be delivered via non-physics or engineering modules (i.e. Project management).

7 Research Project Component Learning Outcomes (FHEQ Level 7)

7 – Research Project Component Learning Outcomes (FHEQ Level 7)

These 'subject area' learning outcomes are mapped to the 'programme-wide' learning outcomes, labelled |i.e. [A1] or [A4].

The student must be able to (both streams):

P1. Demonstrate self-direction and originality in planning tasks and solving problems during a research project. **[A2, A6, A9]**

P2. Prepare a comprehensive review or critical evaluation of existing research literature and/or professional guidance on a specific topic. **[A7, A8, A9]**

P3. Evaluate the research findings in relation to applicable techniques, theoretical limitations and experimental or design considerations. **[A2, A10]**

P4. Analyse data showing originality in their interpretation in relation to scientific literature. **[A5, A10]**

P5. Synthesise appropriate conclusions and findings through knowledge and systematic understanding of the research process and any limitations of the work. **[A1, A8, A10]**

P6. Communicate the outcomes of research or product development to professional standards through established dissemination routes, such as a dissertation, poster and oral presentations. **[A8]**

P7. Apply ethical considerations in the design and preparation of a research project through compliance and/or awareness of local ethics committee procedures or Home Office processes for animal research, where relevant. **[A7]**

8 References

1 The revised UK Quality Code for Higher Education (2018) https://www.qaa.ac.uk/quality-code (Accessed December 2020)

2 https://www.qaa.ac.uk/docs/qaa/quality-code/qualifications-frameworks.pdf

3 BLOOM, B. S. (1956). **Taxonomy of educational objectives; the classification of educational goals**. New York, Longmans, Green

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