The IPEM Masters Level Accreditation Framework (MLAF)

Version 1.3
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This MLAF Handbook is valid for Higher Education Institute (HEI) assessments from January 2018 and will apply for new accreditation assessments no later than September 2020 at which point an updated handbook will be released.

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CHAPTER ONE: EDUCATIONAL CONTENT OF FRAMEWORK

1.1 Summary
Medical physicists and biomedical engineers are employed in hospitals, in industry, in universities and, to a lesser extent, in government departments. The previous IPEM accreditation scheme for masters programmes (last updated in 2010 within the ‘blue book’ IPEM Training Prospectus) focussed primarily on accrediting degrees for the United Kingdom NHS hospital training scheme. However, the changeover to a new ‘Modernising Scientific Careers’ training scheme in England and Wales from 2010 meant that IPEM no longer fulfilled that role. Moreover, the growth of university and industrial employment in several innovative fields of physics and engineering applied to medicine, such as implant devices, tissue engineering and charged particle therapy, gave IPEM a timely opportunity to redefine and broaden the accreditation scheme. It is now designed to be inclusive for postgraduate taught programmes at QAA Framework for Higher Education Qualifications (FHEQ) Level 7 across a whole spectrum of medical physics and bioengineering fields. The new accreditation scheme (developed in 2014 and revised in this document) aims:

\[\textit{to ensure that graduates of accredited programmes are equipped with the knowledge and skills for the medical physics or biomedical engineering workplace, be that in industry, healthcare or academic environments.}\]

The educational standards and processes of the accreditation framework are governed by a Masters Level Accreditation Framework (MLAF) that is described both educationally (Chapter 1) and operationally (Chapter 2) within this document. In Chapter 1, this is presented for purposes of constructive alignment by taking this overall M-level programme aim, above, and expanding it into a series of programme-wide learning objectives that cover core areas of knowledge and skill in physics and engineering fields related to medicine or biology. Specific learning outcomes for outlined ‘subject areas’ in medical physics or biomedical engineering are then further defined. The strength of this approach lies in its educational robustness, with use of well-established Blooms/SOLO taxonomy for nomenclature, as well as the ability subsequently to map learning objectives back and forth from specific ‘subject areas’ to ‘programme-wide’ outcomes and on to established national education and training frameworks.

The QAA Document entitled ‘Master's degree characteristics’ (2010)\(^1\) sets out the defining characteristics of a masters degree. While accepting that masters degrees are planned with different intentions and may be full-time or part-time, it sets out (Appendix 1) some general guidelines for degrees which are intended to be for specialised/advanced study. It is expected that degrees accredited under this IPEM framework will follow these guidelines.

For engineering and physics respectively, the national frameworks are the UK-SPEC (Engineering Council) (updated 2016)\(^2\) and the Physics Subject Benchmark Statements (Quality Assurance Agency) (updated 2008)\(^3\). Due to the dual nature of frameworks, this MLAF has two parallel streams, an engineering stream and a physics stream. These share many subject area learning outcomes, but specialise in four parts, as shown on the next page.

The overall MLAF structure, for both physics and engineering streams, is shown overleaf (Figure 1).
1.2 Framework description
The design of the framework requires the splitting of the learning outcomes into engineering and physics streams for four subject areas, meaning that a single programme from an HEI would be normally accredited for only one stream: engineering or physics. However, the option to comply with both streams does exist if an HEI can deliver a notably broad spectrum of module choices across their programme.

A UK credit point, also known as a Credit Accumulation and Transfer Scheme (CATS) point, is 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 is multi-level and three levels, called components, exist above the ‘broken line’ in Figure 1. This ‘broken line’ defines the boundaries of undergraduate and postgraduate subject level description, or in more educational terminology, represents the QAA Framework for Higher Education Qualifications (FHEQ) benchmark for level 6. To complete a masters degree, a 180 UK credit points degree must be successfully completed by a student, of which 150 points must be at FHEQ Level 7. Thus, a student can only complete 30 UK points from below the ‘broken line’ from the ‘entry component’, as discussed later, in his/her accumulation of points from successfully completed modules, to obtain a masters degree award.

The framework lists learning outcomes within ‘subject area’ components. However, there is no obligation or expectation for HEI programme directors to deliver content within modules that match these fixed ‘subject area’ blocks; the onus is on HEIs to demonstrate that their programme achieves all the framework learning outcomes for the relevant stream (physics or engineering). Options for module delivery, and the teaching method to meet this aim, are left to the individual HEI to decide.

For the framework shown in Figure 1, students must satisfy all the learning outcomes for each component. These learning outcomes are published later in Chapter 1 and are divided into the ‘subject area’ boxes shown for each component of the framework level. In some ‘subject areas’ there is both an engineering and a physics stream for a single ‘subject area’, as made clear by the shading of boxes. To encourage flexibility, the ‘subject areas’ themselves serve only as a guide to the structure of a masters programme, and HEIs are free to divide up components above the ‘broken line’ into bespoke modules as they see fit, provided all learning outcomes within each component are achieved by the students. If a complex arrangement is proposed, this should be described in the application documents clearly. There is no restriction over the study sequence in which components, or module ‘subject areas’, are taught or delivered to students.

1.2.1 The ‘compulsory component’
The ‘compulsory component’, above the ‘broken line’, contains learning outcomes considered by the authors 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. This relaxed rule permits different points increments to be used by different HEIs for modules according to their institution policy for academic credit of modules. For example, module allocation is known to be awarded by different UK HEIs in incremental units of 5, 7.5, 10, 20 or 30 UK points.

Since the authors consider it to be important for students to meet all the learning outcomes covered in the compulsory component, it is not expected that there will be more than a very small allowance of ‘condoning’ (i.e. students being allowed to pass a module between 40 and 50% if they have done sufficiently well elsewhere).
1.2.2 The ‘specialist component’

The ‘specialist component’ is intentionally designed without prescribed learning outcomes to encourage Higher Education Institute diversification across medical physics and biomedical engineering at masters level. In this component the HEI programme leaders can design their own learning outcomes for two or more separate and distinct modules. It also enables institutes to focus on their marketable local strengths and assists them in designing and adapting their programmes to suit the needs of their students. ‘Specialist component’ module learning outcomes will be scrutinised individually by Assessors at accreditation assessments and visits.

These learning outcomes must comply with Blooms/SOLO taxonomy in their development, follow established rules on their structure and should predominantly reach FHEQ Level 7 descriptor level. The specialist level provides HEIs with an opportunity to diversify the title of their masters level degree, offering for example: ‘Radiation physics with proton therapy’, ‘Biomedical and optical engineering’ or ‘Medical Imaging with instrumentation’.

Up to 25% of points awarded at the ‘specialist component’ level can 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’. It is hoped that the flexibility of this ‘specialist component’ will foster novel course delivery both in terms of new emerging topics of medical physics and biomedical engineering content for modules and in terms of options for research-led teaching or other non-lecture based methods of teaching delivery such as problem-based or enquiry-based learning.

The authors recognise that medical physics and biomedical engineering covers specialisms in widely differing areas of the physical sciences and engineering. Often there is a problem in deciding whether there is a satisfactory balance in a particular programme between a breadth of topics, giving a student an adequate overall view of the inter-related applications of physics or engineering in medicine, and the study in-depth of a limited range of topics expected of FHEQ Level 7.

A general philosophy to balance these demands is suggested, as such:

(i) sufficient diversity of knowledge to appreciate the common principles underlying the wide range of applications of physical sciences and engineering to medicine.

(ii) sufficient depth of knowledge in selected topics to address specialised application.

To satisfy the in-depth criterion in a given specialised area, the level of knowledge must be sufficient that after completing a masters research project in the same subject area, the individual would be capable of practising under supervision in a junior role in that particular branch of medical physics and biomedical engineering.

1.2.3 The ‘research project component’

The ‘research project component’ is less flexible than other components above the ‘broken line’ and is fixed at 60 UK points, as this is the UK Higher Education sector standard for FHEQ Level 7 qualifications. 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. The project should be hypothesis-based work that includes an experimental, computational or theoretical aspect, as well as a literature review of the field of investigation within its work. This component must be ‘passed’. However, the rules which determine the classification of a masters award (i.e. pass, merit, distinction) are fully determined by the HEI according to its educational processes. This is highlighted because some HEIs state a minimum mark from the project module for a certain masters degree classification (i.e. ‘65% or more at the project level is additionally required for a pass with merit’). This framework does not wish to interfere with such institutional policies.

Additionally, a talk and poster activity must be completed by the student during their degree to foster communication skills. These two student activities need not be completed in same module, or even the same framework component, but one logical approach may be to use the self-directed
work of the research project to show individualised student work in posters and/or presentations. At least one of these activities must be assessed summatively.

1.2.4 The ‘entry component’
This entry level is shown in Figure 1 below the ‘broken line’, which represents the Quality Assurance Agency for Higher Education (QAA) benchmark statement standard for FHEQ level 7. The educational content for the entry level is therefore taught at FHEQ Level 6, which means that a maximum of 30 UK points can be transferred to the masters award, as per UK Higher Education conventions. Thus, individual students can only transfer up to 30 points of academic credit from the ‘entry component’ to their accredited masters award, even if they have had to sit and pass modules with a combined total of more than 30 points due to their diverse background. This explains the masters award criteria in Figure 1 as ‘≥ 180 points’ of completed and passed module content.

In the ‘entry component’, modules are strictly defined. It is therefore necessary for HEIs to deliver modules within the shown subject areas to ‘top up’ the educational attainment of students up to FHEQ Level 7 in each subject area. HEIs are free, however, to rename these modules and merge them as appropriate into combined modules. To aid flexibility, there is no minimum points allocation for each study 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. It enables completion of an accredited programme by students with differing, but appropriate, educational backgrounds to the traditional physics or engineering undergraduate degree. Therefore, the subject areas of this entry level that an individual student must complete depend on their previous educational background (or acquired workplace skills, under some cases). Thus, they need not achieve all the learning outcomes in the ‘entry component’, being waived the need to demonstrate attainment, as outlined below.

The assessment of the individual’s suitability to be waived certain ‘entry component’ modules is undertaken by the programme director rather than IPEM, with guidance from this section. There is, however, an annual audit process undertaken by IPEM to monitor the decisions of the programme director, as described in Section 2.4, to ensure consistency across all accredited programmes and offer feedback and support to the programme leader in their actions. The programme director can also contact the IPEM lead for the framework, through the framework administrator, to discuss particular cases if there is uncertainty or an unusual case.

Each applicant must be separately assessed as to their study requirements within the ‘entry component’ by the programme director. Applicants who are able to demonstrate attainment to FHEQ level 7 for all the learning outcomes of one entry level ‘study area’ are waived the requirement to study that block by an HEI programme director. One way a programme director may record their actions in a time effective manner is by keeping a spreadsheet file of applicants, detailing their waived modules and a short note of justification as to why exemption was granted i.e. ‘Medical degree’, ‘Liverpool Electrical Safety course 2013 & HSE Course 2012’. It is encouraged to submit this during the annual course audit.

So, for example, a physics graduate would be reasonably waived the need to study ‘Core Physics’ at entry level for a physics stream programme, as s/he would have achieved this benchmark in undergraduate studies. Similarly, a graduate of medicine would clearly meet the benchmark for the ‘Life Sciences’ subject area, and be exempt from this ‘entry component’ subject.

Students waived from certain ‘subject areas’ will still need to acquire 180 UK points in total to graduate, so would need to acquire additional academic credit from elsewhere, most likely the ‘specialist component’. Some examples of common waived module scenarios are shown below in Table 1. While appearing complex at first glance, the ‘entry component’ is simplified if a strict intake of applicants with fixed entry criteria is applied. For example, if all students have an honours degree in engineering or physics, then this ‘Core Physics/Engineering’ subject area can be exempt for the whole cohort, with ‘Life Sciences’, ‘Health & Safety’ and ‘Information Literacy’ the areas requiring delivery to the whole cohort.

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<td>Revised by:</td>
<td>Jo Pearson</td>
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Table 1: Common examples of waived modules at entry level

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<tr>
<th>Entry ‘subject area’</th>
<th>Common justification for waiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Core physics’</td>
<td>Applicant has an honours degree in physics and is taking a physics stream masters programme.</td>
</tr>
<tr>
<td>‘Core engineering’</td>
<td>Applicant has an honours degree in engineering and is taking an engineering stream masters programme.</td>
</tr>
<tr>
<td>‘Life sciences’</td>
<td>Applicant has an honours degree in medicine.</td>
</tr>
<tr>
<td>‘Life sciences’</td>
<td>Applicant has completed an honours degree where learning outcomes are clearly met (i.e. BSc Physiology, BSc Anatomy and Human Biology).</td>
</tr>
<tr>
<td>‘Life sciences’</td>
<td>Applicant can demonstrate learning outcome achievement through extensive work experience related to anatomy and physiology and/or CPD in last 5 years.</td>
</tr>
<tr>
<td>‘Health and safety’</td>
<td>Applicant has evidence of meeting all learning outcomes via a workplace training portfolio, CPD or educational/professional qualification in the previous five years.</td>
</tr>
<tr>
<td>‘Information literacy’</td>
<td>Applicant has completed a PhD, an MSc thesis or another 3000 word or more piece of extended in English that was submitted for academic scrutiny and assessment.</td>
</tr>
<tr>
<td>‘Information literacy’</td>
<td>Applicant has a track record of peer-reviewed publication over the last five years.</td>
</tr>
</tbody>
</table>

The Information Literacy ‘entry component’ can be enforced as mandatory for all students on a programme by the IPEM framework panel, or a programme course team, should an unacceptable level of plagiarism or academic integrity be apparent in the annual audit return or in other educational quality assurance processes. External examiners are encouraged to see this as a possible recommendation to assist in raising academic integrity across a whole programme.

1.3 Learning outcomes mapping

Tables 2 and 3 overleaf map whole-programme learning outcomes within this IPEM accreditation framework document to the most relevant FHEQ Level 7 descriptor for engineering and physics.

For M-level engineering programmes, the FHEQ Level 7 descriptors are within the 2014 publication of ‘UK-SPEC’ (edition three), mapped in Table 2. For M-level physics programmes, this is the ‘QAA framework for higher education qualifications in England, Wales and Northern Ireland’ (2008), mapped in Table 3. While this is last document not UK-wide, it is considered to be the best available document to fit the 2014 Medical Physics educational landscape within the United Kingdom.
Table 2: The IPEM-MLAF engineering stream mapping to UK-SPEC. The right hand column includes the relevant ‘Programme-Wide’ learning outcomes for this framework. i.e. ‘A1’ or ‘A4’

<table>
<thead>
<tr>
<th>UK-SPEC (2016) for CEng</th>
<th>IPEM-MLAF (2014) Program-wide learning outcomes (Section 1.4)</th>
</tr>
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<tbody>
<tr>
<td>C.Eng. requires several years of additional workplace skills and experience</td>
<td></td>
</tr>
<tr>
<td>A2. Engage in the creative and innovative development of engineering technology and continuous improvement systems.</td>
<td>A7 &amp; postgraduate work experience.</td>
</tr>
<tr>
<td>B1. Identify potential projects and opportunities.</td>
<td>A1, A2, A3, A6, A9, A10 and postgraduate work experience.</td>
</tr>
<tr>
<td>C1. Plan for effective project implementation.</td>
<td>A4, A5, A6 and postgraduate work experience.</td>
</tr>
<tr>
<td>C2. Plan, budget, organise, direct and control tasks, people and resources.</td>
<td>A4 and postgraduate work experience.</td>
</tr>
<tr>
<td>C3. Lead teams and develop staff to meet changing technical and managerial needs.</td>
<td>Postgraduate work experience required.</td>
</tr>
<tr>
<td>C4. Bring about continuous improvement through quality management.</td>
<td>A6, A7, A9 and postgraduate work experience.</td>
</tr>
<tr>
<td>D1. Communicate in English with others at all levels.</td>
<td>A6, A8 and postgraduate work experience.</td>
</tr>
<tr>
<td>D2. Present and discuss proposals.</td>
<td>A4, A8 and postgraduate work experience.</td>
</tr>
<tr>
<td>D3. Demonstrate personal and social skills.</td>
<td>A6, A8 and postgraduate work experience.</td>
</tr>
<tr>
<td>E1. Comply with relevant codes of conduct.</td>
<td>A4 and postgraduate work experience.</td>
</tr>
<tr>
<td>E2. Manage and apply safe systems of work.</td>
<td>A4 and postgraduate work experience.</td>
</tr>
<tr>
<td>E3. Undertake engineering activities in a way that contributes to sustainable development.</td>
<td>Postgraduate work experience required.</td>
</tr>
<tr>
<td>E4. Carry out and record CPD necessary to maintain and enhance competence in own area of practice.</td>
<td>Postgraduate work experience required.</td>
</tr>
<tr>
<td>E5. Exercise responsibilities in an ethical manner.</td>
<td>Postgraduate work experience required.</td>
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Table 3: The IPEM-MLAF Physics stream mapping to the QAA framework for physics. The right column includes the ‘Programme-Wide’ learning outcomes of this framework. i.e. ‘A2’ or ‘A5’

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<tr>
<td>*Objectives 9-11 represent skills development in the postgraduate workplace</td>
<td>Programme-wide learning outcomes (section 3)</td>
</tr>
<tr>
<td>1. A systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of their academic discipline, field of study or area of professional practice.</td>
<td>A1, A3, A4 and A7.</td>
</tr>
<tr>
<td>2. A comprehensive understanding of techniques applicable to their own research or advanced scholarship.</td>
<td>A1, A3 and A5.</td>
</tr>
<tr>
<td>3. Originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in the discipline.</td>
<td>A2, A4 and A10.</td>
</tr>
<tr>
<td>5. Conceptual understanding that enables the student: to evaluate methodologies and develop critiques of them and, where appropriate, to propose new hypotheses.</td>
<td>A1, A3, A4, A5 and A10.</td>
</tr>
<tr>
<td>6. Deal with complex issues both systematically and creatively, make sound judgements in the absence of complete data, and communicate their conclusions clearly to specialist and non-specialist audiences.</td>
<td>A1, A3, A4, A5, A8 and A9.</td>
</tr>
<tr>
<td>7. Demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing tasks at a professional or equivalent level.</td>
<td>A2, A4, A5, A6, A7 and A9.</td>
</tr>
<tr>
<td>8. Continue to advance their knowledge and understanding and to develop new skills to a high level.</td>
<td>A9 and postgraduate work experience.</td>
</tr>
<tr>
<td>9. Holders will have the qualities and transferable skills necessary for employment requiring the exercise of initiative and personal responsibility.</td>
<td>Postgraduate work experience required.</td>
</tr>
<tr>
<td>10. Holders will have the qualities and transferable skills necessary for employment requiring decision-making in complex and unpredictable situations.</td>
<td>Postgraduate work experience required.</td>
</tr>
<tr>
<td>11. Holders will have the qualities and transferable skills necessary for employment requiring the independent learning ability required for continuing professional development.</td>
<td>Postgraduate work experience required.</td>
</tr>
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</table>
1.4 Framework ‘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.
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.

1.5 ‘Entry component’ learning outcomes (FHEQ Level 6)

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

1.5.1 ‘Health and 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.

1.5.2 ‘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.

1.5.3 ‘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).

1.5.4 ‘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.

1.5.5 ‘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.

1.6 ‘Compulsory component’ learning outcomes (FHEQ Level 7)

1.6.1 ‘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], and found from page 12.

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]

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]

1.6.2 ‘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]
1.6.3 ‘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]

1.6.4 ‘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]
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]

1.6.5 ‘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]

1.6.6 ‘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]

1.6.7 ‘ICT and signal processing’ 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]

1.7 ‘Specialist component’ learning outcomes (FHEQ Level 7)
To be submitted by individual HEI programme directors for each specialist module. Further guidance for HEI programme directors and Assessors is found in Section 1.2.3 of this document.

These learning outcomes are written by each HEI and will be scrutinised in detail during accreditation assessments. Each should link to ‘programme-wide’ learning outcomes found from page 12 and be labelled accordingly with the link (e.g. [A10]).

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

1.8 ‘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], and found from page 12.

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]
1.9 References
CHAPTER TWO: GOVERNANCE OF FRAMEWORK

2.1 Background information
This MLAF was developed from an IPEM Accreditation Working Group, chaired by Professor Richard Lerski, after a roundtable meeting of 17 UK programme leaders of medical physics and biomedical engineering programmes during November 2012. The meeting, and its subsequent survey of programme leaders, lead to a report to IPEM council\(^1\) that highlighted a strong demand for accreditation services at masters level provided that new processes and standards could be developed to serve the wider medical physics and bioengineering community. This would replace the previous IPEM MSc accreditation scheme, which ran successfully for two decades with twenty accredited programmes by 2010, but which served only hospital sector employment through its aim to ensure ‘a knowledge base suitable for the IPEM Training Scheme’.

Widespread changes to the training of healthcare scientists and engineers in England and Wales since 2010 have made this old accreditation scheme redundant. Moreover, data from the retrospective survey of roundtable attendees in 2012 suggested that only around 40% of UK graduates from these masters programmes were seeking same-sector employment in the NHS or private hospital sector. Of the remaining 60%, around half were seeking employment in industry, while the other half entered the academic sector via further study, research or academic appointment. The report to IPEM council suggested developing a new framework to meet this changed landscape for postgraduate education in medical physics and biomedical engineering through three principles:

- A new framework offering greater flexibility for HEIs to tailor course content to local strengths in research or staff expertise in a changed HEI funding landscape.
- New framework outcomes that are better linked to student employability, with accreditation serving as a kitemark of educational quality/relevance for employers in academia and industry as well as the NHS or private hospital sector.
- A new framework design that addresses the growing interdisciplinarity of student cohorts, allowing accreditation to be inclusive and relevant to students with a first degree outside physics or engineering (e.g. medicine, computing, life sciences).

The work of an IPEM Accreditation Working Group, consisting of the four publication authors, with valuable contributions from expertise named on the final page of this document, led to a new accreditation framework completed for launch in 2014 for UK programmes. The scheme was expanded to include accreditation of international programmes in 2016.

2.2 The IPEM Masters Level Accreditation Framework (MLAF)

2.2.1 Framework governance
The governance of the MLAF is delegated by IPEM Trustees to the Course Accreditation Committee (CAC) that governs all IPEM course accreditation activities and reports to the IPEM Professional and Standards Council (PSC). The CAC maintains a pool of trained academic Assessors to undertake accreditation assessments for IPEM’s MLAF. The pool consists of Assessors nominated by accredited HEIs (see section 2.4) and/or will be respected medical physicists or biomedical engineers appointed for their expertise with respect to the specialisms of the course being assessed.

Administrative support is provided by the IPEM Membership and Training Manager, who is the first point of contact for enquiring and applying HEIs. The Chair of CAC is the first point of contact for communicating accreditation decisions to HEIs and for answering queries from programme directors about accreditation.

\(^1\) Harle J, ‘Summary and Recommendations from the IPEM Accreditation Workshop of 8th November 2012’ white paper to IPEM Council, Jan 2013.
2.2.2 Framework website
Application guidance and paperwork, together with a list of accredited courses and HEI contacts can be found on the IPEM MLAF webpage. This is maintained by the IPEM Membership and Training Manager and can be accessed here.

2.2.3 The MLAF Assessors
The MLAF Assessors represent a range of expertise in physics and engineering applied to medicine. Assessors are typically academics with experience in the delivery of MSc teaching in related fields; they are inducted to their Assessor role by an experienced Assessor supplemented by training material to ensure consistent assessment standards across all accredited programmes.

2.2.4 Framework updates
Periodic updates to the framework will be published on framework website and major reviews of the framework are carried out as required.

2.3 Applications for accreditation
2.3.1 The application process
Applications are to be encouraged from HEIs within the UK and from other countries. A range of programme titles may be acceptable for programmes, including those that are more specialist than the traditional ‘MSc Medical Physics’ or ‘MSc Clinical Engineering’, as the new framework permits.

All programmes will be assessed against this framework, and its component learning outcomes, and HEIs will be expected to demonstrate, through paperwork returns and a site visit by two MLAF Assessors, how their programme meets the learning outcomes in each component of the framework. Programmes applying for accreditation will also be expected to outline their suggested modules and learning outcomes, as well as be scrutinised against many other aspects of their teaching, its delivery, its processes and its administration. ‘Specialist component’ learning outcomes of a masters course will need to be outlined in detail for each application.

Applications should be made through the IPEM Membership and Training Manager, who can be contacted via membership@ipem.ac.uk and who will normally acknowledge receipt of an application within a maximum of three weeks from receipt. Applications are subject to a fee to cover costs – these are outlined on the website and represent an administration fee paid to IPEM directly at application, as well as reasonable expenses for the Assessors (see Section 2.3.6). As Assessors work for expenses-only, their contribution is highly valued, and they should be treated with respect at all stages of a site visit and during any follow-up requests during the writing of their report. Assessors have their expenses paid directly by the applying HEI, and are entitled to withhold their assessment report should they be concerned about appropriate refunding of their expenses.

As MLAF Assessors conduct activities on an unpaid basis as part of their professional duties, HEIs should be mindful of the voluntary nature of accreditation framework activities and plan suitable timeframes for making an accreditation application. This is particularly true in times of high demand for accreditation assessments and during periods where university holidays may impact on Assessor availability. It is not unreasonable for a UK-based accreditation assessment to take more than 6 weeks from receipt of appropriate paperwork to suggestion of dates for a site visit, and another 6 weeks for a decision to be made after the site visit, following recommendations and completion of follow-up questions to the HEI by its Assessors.

2.3.2 The assessment process
This will be conducted by both paperwork scrutiny of the application form and a one day site visit by two MLAF Assessors.

Following scrutiny of the paperwork and site visit, a confidential report will be written by the two Assessors and circulated to the other MLAF Assessors for electronic discussion by email and a
short teleconferencing meeting to form a collective decision. A final decision will be made after this meeting, and communicated by the Chair of CAC to the HEI, to:

- ‘Accept’ – this is subject to complying with annual requirements outlined in Section 2.4.
- ‘Accept subject to minor recommendations’ – these recommendations will be outlined to the HEI. Upon satisfactory addressing of these recommendations, within an agreed time limit, through correspondence with the Chair of CAC, the application will be reconsidered by those MLAF Assessors who had participated in the original electronic discussion and/or the teleconferencing meeting.
- ‘Re-apply with major recommendations’ – in this case, it is judged that too many changes are needed for a simple re-consideration of the updated application. It is advised that the HEI redesign its educational content to better meet the required standard before starting a new application.
- ‘Reject’ – this case is for applications which fall far short of the required standard. Feedback will be given by the Chair of CAC as to why this decision was made.

The decision and report will be announced to the HEI programme director by the CAC Chair normally within 6 weeks of the Assessors’ visit, alongside justification for the decision and recommended steps to comply with the framework, if needed.

A separate assessment will be required for each HEI award and each HEI stream. Therefore an MSc offering separately titled MSc programmes in ‘Medical Physics’ and ‘Medical Physics Computing’ will need to complete two separate applications. Similarly, an MSc programme in ‘Physics and Engineering in Medicine’ will need to choose its appropriate stream for accreditation (physics or engineering) or submit two applications. Site visits for dual or multiple assessments may be combined.

The paperwork and meeting minutes that judge HEI programme quality and suitability will be confidential, as will the justification statement of the panel and its subsequent recommendations.

The spirit of the accreditation process is one of supporting HEIs to meet the required standards set out in this framework document, and a culture of openness is encouraged at site visits and subsequent follow-up enquiry to assist Assessors in gathering the information they need. Openness also helps the Assessors in making well-informed recommendations, if any are required, that are straightforward and cost-effective for the HEI to adhere to subsequently gain accreditation status.

2.3.3 The site visit
Typically, the site visit will involve two Assessors and take place over one working day per HEI accreditation application. It should be viewed as an exercise in outlining the programme to an unfamiliar academic colleague and used as an opportunity to clarify the information within the accreditation documentation. The Assessors will normally be in contact with programme director to arrange a date for the site visit and to determine a suitable itinerary.

The itinerary for the Assessors’ visit is the primary responsibility of the individual Assessors but the following is a list of possible elements that have proven useful in previous evaluations:

- Initial meeting for discussion and feedback with staff holding key responsibilities, including short initial presentation from the programme director outlining the programme (s)
- Subsequent discussion of aspects of the programme with as many teaching staff as possible
- Demonstration of any innovative aspects of teaching delivery
- Demonstration of how communications skills will be learned (i.e. talk/poster)
- Private inspection of examination material, some marked scripts and project material
- Private discussion with a selection of students
- Private time for Assessors to consider their decisions
- Final meeting to examine accreditation documentation with the programme director
2.3.4 The appeals process
Any HEI which has a submission for accreditation turned down may appeal in accordance with the procedures set out below. The grounds for appeal may only be made on one or more of the following grounds:

1. There is evidence of administrative, procedural or other irregularities in the conduct of the accreditation visit or other aspects of the accreditation process;
2. Information has become available which would influence the decision and which was not, and could not, have been available at the time of the accreditation or review visit.

Should a HEI be dissatisfied with the outcome of the accreditation process it must make this known in writing or email to the Chair of the CAC within two weeks of the final approved report and accreditation decision. If, after corresponding with the Chair of the CAC, the HEI remains unsatisfied, it may make a formal appeal. The IPEM Vice President (Academic) is, in these circumstances, appointed to independently review the case and make a final decision, using resources s/he deems necessary. The HEI may be asked by the Vice President (Academic) to submit written reasons for wishing to appeal.

In reaching a decision the Vice President (Academic), or persons appointed by him/her, will review the documents submitted to the MLAF Assessors, the report of the Assessors, the written justification by the Assessors, further thoughts from Assessors and the HEI’s reason for appeal. The decision of the Vice President (Academic) will be final.

2.3.5 Length of accreditation status
At the first assessment of a masters programme under this framework, accreditation status will be granted for 3 years. Subsequently, with a track record of good practice, it will be granted for 5 years. All accredited programmes must participate in the annual requirements of accredited programmes (Section 2.4), including the audit, and resolve any issues concerning minor changes to the programme in a timely manner to the satisfaction of the Chair of CAC.

The CAC reserve the right to modify the framework standards in subsequent years and publish new versions of this guidance. While it is intended that a programme currently accredited under the framework would not have to demonstrate compliance to new guidance during its awarded period of accreditation, the CAC cannot ignore sector-wide legislative changes or new national standards or guidance, such as QAA recommendations, which involve rapid action. Therefore, on rare occasions, it may be necessary for the CAC to contact programmes within their accreditation status to discuss changes to the programme.

Programmes that fail to comply with additional requirements of accreditation, as outlined in Section 2.4, may be subject to temporary suspension of accreditation status under extreme circumstances.

2.3.6 Accreditation fees
Activities are break-even rather than profit-making. The standard administration fee paid to IPEM for assessment of each HEI award for each stream (physics or engineering) is published on the website here.

Assessors’ travel expenses should be paid directly by the HEI. This will include accommodation and subsistence, if needed, when an Assessor is conducting a visit far from their home or workplace (e.g. Aberdeen to Exeter). No payment is made for the Assessor’s time; they can use this activity as part of annual CPD activities.

Assessors may delay release of their report if not reassured that their expenses will be paid.
2.4 Commitments and benefits of being an IPEM accredited programme

There are some small additional requirements from HEIs to maintain accreditation status and demonstrate good educational practice.

Each accredited programme agrees to complete a brief annual audit for scrutiny by the MASP at its annual face-to-face meeting. The purpose of this audit is primarily to monitor year-on-year changes to a programme, as well as monitor the practice of waiving modules at entry levels for certain groups of appropriately qualified applicants. The programme director of each accredited HEI is responsible for returning the audit form; this will contain the most recently available student data concerning:

i) numbers of student enrolled/graduated.
ii) plagiarism and academic integrity issues.
iii) data on student entry qualifications for those granted a waiver for ‘entry components’.
   This should be a spreadsheet file outlining in columns: waived module; short rationale for waiver (i.e. ‘BSc Physics’, ‘PhD Warwick 2012’, ‘Medical Degree Leeds 2013’). Student names should not be included to preserve confidentiality.
iv) recent external examiner reports.
   There is no wish to interfere in the role of the external examiner, merely to observe if any issues relating to ii) or iii) above have been noted or acted upon.
   v) details of minor changes to the programme in the academic year ahead.
   vi) details of staff changes, with information on the qualifications of new staff members.
   vi) details of two named individuals from the HEI willing to serve in the next 12 months as:
   1. the named Programme Director: IPEM would like this person, or someone nominated by this person, to have the responsibility for organising careers events and talks, and to be the first point of contact for masters students wishing to receive guidance on their career options after graduation. Careers events and talks can be organised in conjunction with the Communications and Development Manager at IPEM (communications@ipem.ac.uk), who can offer published and electronic resources, such as a standard presentation template. The Communications and Development Manager will also contact the designated person to advise him/her of relevant opportunities for the students and staff (for example free media training, grants, new resources or initiatives) and we would ask him/her to pass these on.
   2. the named Assessor: an academic available to join the IPEM pool of MLAF Assessors. S/he will be asked to assist in one site visit per year (and associated report writing) alongside a second MLAF Assessor. This can be submitted as professional activities for CPD purposes and has travel expenses reimbursed.

The annual audit involves a paperwork submission during the autumn months. An email from the IPEM Membership and Training Manager will ask all programme directors to return the audit form in December. Audit forms are needed for scrutiny before the annual CAC meeting in December/January.

IPEM accredited programmes are also currently eligible for the IPEM Student Prize Award Scheme. This scheme, outlined in the link below, enables course leaders from accredited programmes to nominate their best student project each year for an IPEM-sponsored cash prize and certificate, in return for minor publicity obligations. This scheme is maintained by the IPEM Executive Secretary and can be accessed here.

2.5 Waivers for ‘entry component’ modules

Scrutiny will be given at the annual audit to HEI activities in waiving entry level modules for certain applicants. High incidences of plagiarism or poor information in project reports may necessitate the ‘Introduction to information literacy’ entry level subject becoming mandatory for all students on an accredited programme in a number of subsequent years.
The CAC may also make occasional requests for other ‘entry component’ topics becoming mandatory when required to maintain educational standards (i.e. poor adherence to health and safety principles among a cohort in projects making this entry level ‘subject area’ compulsory in subsequent years).

This creates a simple quality control measure for the panel to ensure high standards are maintained in certain key areas where prior knowledge of graduates is normally assumed.
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