EUTEMPE-RX QUALITY ASSURANCE COMMITTEE

Module Approval Form (Content and Organization)

Quality Manual: "All modules forming part of the EUTEMPE-RX module catalogue are required to be formally approved by the **EUTEMPE-RX Education Board** in terms of content and organization prior to delivery. Such approval will be communicated to the module leader/s in writing by the Secretary of the Education Board. The leader/s of the particular module will apply for such approval on the official **Module Approval Form (Content and Organization)** provided by the **Quality Assurance Committee** (QAC). The request for approval should be sent to the Secretary of the Education Board. In its deliberations the Educational Board will take into consideration the recommendations of the QAC. Records of the results of the review of the QAC and any associated actions will be registered by the secretary of the QAC"

PRINCIPLES GUIDING MODULE CONTENT

The following quotes from the key documents of the EUTEMPE-RX project should guide module content and organization:

European Qualifications Framework definition of Level 8
Knowledge: "knowledge at the most advanced frontier of a *field of work* or study and at the interface between fields"
Skills: "the most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and *to extend and redefine existing* knowledge or *professional practice*"
Competence: "demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research"

European Guidelines on the MPE
"The question arises which of these KSC are expected to be achieved by the medical physics professional at the end of the two years equivalent clinical training following the Masters in Medical Physics (EQF level 7+) and which at the MPE level (EQF level 8). In general most of the knowledge, a substantial number of the skills and some of the competences should be acquired by the end of the initial two year clinical training. The skills and competences to be acquired by the end of the two years equivalent clinical training following the Masters in Medical Physics (EQF level 7+) are those defined by the IAEA training documents (Clinical Training of Medical Physicists Specializing in Diagnostic Radiology. Training Course Series, 47, IAEA, 2010, http://www-pub.iaea.org/MTCD/publications/PDF/TCS-47_web.pdf). However, as Medical Physics is by nature complex it must be emphasized that these skills and competences are developed over a period of years. *The majority of the skills and competences would be acquired to the appropriate effective and safe level only at the MPE level i.e., level 8*"

EUTEMPE-RX Quality Manual
"*EUTEMPE-RX will focus on the development of skills and competences to EQF level 8*. Knowledge learning outcomes will also be included when the knowledge level presently acquired in Level 7 programmes is considered insufficient for the development of skills and competences to level 8"

EUTEMPE-RX Project Description-of-Work:
"Each module should typically include:

- a clearly defined topic
- list of KSC to be achieved in line with the key activities of the MPE as formulated in the 'European Guidelines for the MPE' project and in accordance with interests formulated by MELODI, DOREMI and HLE
- both theoretical and practical training sessions
- a state-of-the-art literature review and collection of educational material on the topic
- an example on how to transfer research results to clinical practice
- an example of innovation
- the use of associated software tools
- a practical challenge to be solved
- a module evaluation method and evaluation moment

ABSTRACT

The first two pages of the Module Approval Form are dedicated to an ABSTRACT which describes the module content and organization in brief. Please keep to the desired format. This abstract will be presented on the EUTEMPE-RX webpage and used for PR activities. Often potential participants only have time to read the abstract. The abstract must therefore be striking and informative enough to stimulate interest in potential participants.

Notes:

a) The abstract should be 2 pages maximum
b) The module code is *MPEmodulenumber (e.g., MPE01 to MPE12)*
c) Use font calibri size 10
d) Each module is very comprehensive and will address a large number of KSCs from the 'Inventory of Learning Outcomes for the MPE in Europe' (rp174_annex1 of the 'European Guidelines on the MPE). These KSCs will be found in the full module description. The **Summary Learning Outcomes** in the abstract represent a brief summary of these KSCs.
e) The numbering of the Summary Learning Outcomes should be in the form *MPEmodulenumber.summarylearningoutcomenumber (e.g., MPEXX.01, MPEXX.02...)*
f) **Please remember that these are all level 8 modules.** Therefore use **ONLY level 8 action verbs** for the Summary Learning Outcomes e.g., take responsibility for, implement, manage, evaluate, research, lead, design, develop, discuss...

Module MPE05: Anthropomorphic Phantoms

ABSTRACT

Title: The use of physical and virtual anthropomorphic phantoms for image quality and patient dose optimization

Module Code: MPE05

Module Level: EQF level 8

Aims: Anthropomorphic phantoms permit safe unlimited exposure and are intended for use in image quality and patient dose optimization, clinical commissioning and pre-clinical trials in health technology assessments. The module aims to familiarize participants with the role of the physical and virtual anthropomorphic phantoms and the possibility of performing virtual (phantom-based) clinical trials using existing and new Diagnostic and Interventional Radiology (D&IR) technologies. Participants will be introduced to different existing types of anthropomorphic phantoms, used in clinical trials and will be encouraged to develop skills for the design and evaluation of anthropomorphic phantoms, as well as design, manage, implement and evaluate virtual clinical studies with such phantoms and discuss and interpret the results of the virtual studies. Teaching methodology includes face-to-face and e-learning approaches. The course is organized in a mixed format that includes lectures, computer-based exercises, visits to hospital for experimental work and discussion sessions. Participant assessment will consist of a work project (based on a case study from D&IR), combined with a written exam.

Learning Outcomes: At the end of the module the participants will be able to:

MPE05.01 Demonstrate knowledge on computational/physical anthropomorphic phantoms and their application in D&IR.
MPE05.02 Design and implement new physical and virtual anthropomorphic phantoms.
MPE05.03 Use of software tools to design anthropomorphic phantoms.
MPE05.04 Run virtual clinical and research studies with anthropomorphic phantoms to optimise or develop a clinical protocol.
MPE05.05 Run virtual clinical and research studies with anthropomorphic phantoms to assess the capabilities and limitations of an imaging modality.
MPE05.06 Run virtual clinical and research studies with anthropomorphic phantoms to optimise the parameters of an existing imaging device.
MPE05.07 Run virtual clinical and research studies with anthropomorphic phantoms to develop and evaluate image enhancement techniques.
MPE05.08 Run virtual clinical and research studies with anthropomorphic phantoms to develop and evaluate image reconstruction algorithms.
MPE05.09 Simulate an imaging experiment prior to its real setup.
MPE05.09 Supervise image reconstruction and image handling procedures.
MPE05.10 Run virtual research studies with anthropomorphic phantoms to perform advanced scientific research related to emerging x-ray imaging techniques.
MPE05.11 Understand when, why, and how to use anthropomorphic phantoms in daily clinical practical and research D&IR work.

Date and Location of Face-to-Face Component: **Technical University of Varna, Bulgaria, 7 - 13 September 2015**

Module Leader:

Dr. Kristina Bliznakova (kristina.bliznakova@tu-varna.bg)
MSc and PhD degrees in Biomedical Engineering obtained from University of Patras, Greece. Main research fields: modelling and simulation of existing and novel x-ray breast imaging techniques (mammography, tomosynthesis, phase-contrast, cone-beam CT), development of software anthropomorphic 3D breast models dedicated for x-ray imaging, implementation of Monte Carlo methods for simulation of irradiation transport and dose calculation. Marie Curie fellow at the Technical University of Varna, Bulgaria, carrying out the FP7 PHASETOMO project, which aimed at the investigation of a new technique for accurate breast lesion detection, called phase contrast breast tomosynthesis (2012-2016).

Faculty: Kristina Bliznakova, Ivan Buliev, Hilde Bosmans, Angelo Taibi, Alistair MacKenzie

Delivery of the module: The module will achieve its learning objectives using a combination of face-to-face and online presentations, readings and discussions. The online phase may be performed at any desirable time of the participants, and therefore they would not need to take time off their clinical duties. The face-to-face component will extend over a period of 1 week (5 to 6 working days).

Total participant effort time: 80 hours = 40 hours face-to-face, 40 hours online

Assessment Mode: The assessment of the participants will consist of combined examination, including a work project and a written exam. The work project will be given to the participants combined in groups of 2 to 3 people, at the beginning of the face-to-face phase. It will be carried out throughout the face-to-face duration and will conclude with a short (max 20 min) presentation. The written exam will consist of short questions (most of which will be multiple choice questions) and will have a duration of 2 hours. The final assessment mark will be calculated on the basis of 70% project mark + 30% written exam mark.

Module Homepage: Set by Leuven. Please contact Roman Verraest. **MODULE DATA**			
Module Homepage	Set by Leuven. Please contact Roman Verraest.		
Module Code	MPE05		
Module Leader/s Please limit CV to a max of 250 words and to what is relevant to this module.	Dr. Kristina Bliznakova Senior Researcher, Technical University of Varna, Bulgaria e-mail: kristina.bliznakova@tu-varna.bg MSc and PhD degrees in Biomedical Engineering obtained from University of Patras, Greece. Main research fields: modelling and simulation of existing and novel x-ray breast imaging techniques (mammography, tomosynthesis, phase-contrast, cone-beam CT), development of software anthropomorphic 3D breast models dedicated for x-ray imaging, implementation of Monte Carlo methods for simulation of irradiation transport and dose calculation. Pioneer with the BITU group from the University of Patras in the design, implementation and evaluation of breast tomosynthesis at synchrotron facilities. Marie Curie fellow at the Technical University of Varna, Bulgaria, carrying out the FP7 PHASETOMO project, which aimed at the investigation of a new technique for accurate breast lesion detection, called phase contrast breast tomosynthesis (2012-2016).		
Teaching Staff Teaching staff should be either recognised MPEs or in possession of a PhD. If not please contact the Secretary of the QAC.	Dr. Kristina Bliznakova, PhD Assoc. Prof. Ivan Buliev, PhD Prof. Hilde Bosmans, PhD, MPE Ass. Prof. Angelo Taibi, PhD Dr. Alistair MacKenzie, PhD		
Candidate Assessment	**Written Assessment:**		Written exam with short and precise questions, including multiple choice, max duration of 2 hour.
	Practical Assessment:		Work project given to the participants combined in groups of 2 to 3 people
Module Duration The TOTAL number of hours of participant effort should be about 80. (including lectures,	**Online phase** Asynchronous methods should be used whenever possible so that participants would not need to take time off	The online component will be spread over a period of approximately 3 - 4 weeks and would require approximately 40 hours of reading and effort by the participants. The online phase will be mostly asynchronous so that participants would not need to take time off their clinical duties.	

reading of assigned compulsory texts, participation in online fora etc)	their clinical duties and there will not be a problem with time zones. However synchronous methods (evenings or weekends only) should be used when crucial.	
	Face-to-face phase Must include 1 day for revision and 1 day for the assessment proper.	The face-to-face component will include a period of 1 week distributed as following: 4 days content delivery, 1 day for revision, 1 day for assessment. All modules: All learning materials including presentations will be sent to the participants 2 weeks before the first day of the face-to-face phase.
Date and location of Face-to-Face	7 - 12 September 2015 Technical University of Varna, Bulgaria	
Date of Assessment Normally last day of face-to-face phase.	12 September 2015	

Breakdown of participant effort time	**Module Component**	**Estimated Time**
	Online lectures, seminars, tutorials, fora	10 hours
	Online compulsory reading	30 hours
	Face-to-face lectures, seminars, tutorials, fora	30 hours
	Face-to-face technical demonstrations	6 hours
	Face-to-face laboratory/clinical exercises	4 hours
	Total participant effort time	**80 hours**
	Free day for exam preparation day (same for all modules)	**1 day**
	1 day for assessment (same for all modules)	**1 day**

PRE-REQUISITES FOR THE MODULE	
Minimum entry qualifications, training and years of experience for *all* modules Same for all modules	EQF Level 6 in Physics (BSc Physics or equivalent) EQF Level 7 in Medical Physics (MSc Medical Physics or equivalent) 2 year equivalent clinical training in D&IR for clinical Medical Physicists 2 year equivalent Industry/Radiation Authority experience for Industry/Radiation Authority personnel.
Assumed previous KSC for *all* modules from the 'Inventory of Learning Outcomes for the MPE in Europe' (Annex I of the 'European Guidelines on the MPE') Same for all modules	GENERIC SKILLS : Generic Skills Required at EQF level 7 KSC FOR THE MPE AS PHYSICAL SCIENTIST: All Knowledge learning outcomes to EQF level 7 KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL: All Knowledge learning outcomes to EQF level 7 KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION: All Knowledge learning outcomes to EQF level 7 KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY: All Knowledge learning outcomes to EQF level 7 The Skills and Competences included in the IAEA document 'Clinical Training of Medical Physicists Specializing in Diagnostic Radiology' (IAEA Training Course Series, 47, 2010) to EQF level 7.
Pre-requisite EUTEMPE-RX online summary modules for *all* modules	MPE01 Development of the profession and the challenges for the MPE (D&IR) in Europe (online summary version accessible to all participants in all courses)
Additional pre-requisite EUTEMPE-RX online summary modules for *this* module Different for each module.	MPE04 **Advanced X-ray physics for imaging device and user protocol innovation in D&IR**

MODULE CONTENT: AIM and SUMMARY LEARNING OUTCOMES	
Aim	Anthropomorphic phantoms permit safe unlimited exposure and are intended for use in image quality and patient dose optimization, clinical commissioning and pre-clinical trials in health technology assessments. The module aims to familiarize participants with the role of the physical and virtual anthropomorphic phantoms and the possibility of performing virtual (phantom-based) clinical trials using existing and new Diagnostic and Interventional Radiology (D&IR) technologies. Participants will be introduced to different existing types of anthropomorphic phantoms, used in clinical trials and will be encouraged to develop skills for the design and evaluation of anthropomorphic phantoms, as well as design, manage, implement and evaluate virtual clinical studies with such phantoms and discuss and interpret the results of the virtual studies. Teaching methodology includes face-to-face and e-learning approaches. The course is organized in a mixed format that includes lectures, computer-based exercises, visits to hospital for experimental work and discussion sessions. Participant assessment will consist of a work project (based on a case study from D&IR), combined with a written exam.
Learning Outcomes (10 – 15 learning outcomes which provide an overview of the KSC addressed in the module)	MPE05.01 Demonstrate knowledge on computational/physical anthropomorphic phantoms and their application in D&IR. MPE05.02 Design and implement new physical and virtual anthropomorphic phantoms. MPE05.03 Use of software tools to design anthropomorphic phantoms. MPE05.04 Run virtual clinical and research studies with anthropomorphic phantoms to optimise or develop a clinical protocol. MPE05.05 Run virtual clinical and research studies with anthropomorphic phantoms to assess the capabilities and limitations of an imaging modality. MPE05.06 Run virtual clinical and research studies with anthropomorphic phantoms to optimise the parameters of an existing imaging device. MPE05.07 Run virtual clinical and research studies with anthropomorphic phantoms to develop and evaluate image enhancement techniques MPE05.08 Run virtual clinical and research studies with anthropomorphic phantoms to develop and evaluate image reconstruction algorithms MPE05.09 Simulate an imaging experiment prior to its real setup. MPE05.10 Run virtual research studies with anthropomorphic phantoms to perform advanced scientific research related to emerging x-ray imaging techniques. MPE05.11 Understand when, why, and how to use anthropomorphic phantoms in daily clinical practical and research D&IR work.

MODULE CONTENT: TARGET KSC TO BE DEVELOPED TO EQF LEVEL 8 From the 'Inventory of Learning Outcomes for the MPE in Europe' (Annex I of the 'European Guidelines on the MPE')	
KSC targeted in *all* modules These learning outcomes are common to and permeate *all* modules, although to a varying degree according to the topic of the module.	GENERIC SKILLS : All 'Generic Skills Required at EQF level 8' KSC FOR THE MPE AS PHYSICAL SCIENTIST: All Skills and Competences to EQF level 8 KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL: All Skills and Competences to EQF level 8 KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE): All KSC for Scientific Problem Solving Service to EQF level 8 KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY: All KSC for Scientific Problem Solving Service to EQF level 8
***PRIMARY KSC* targeted in *this* module** These are the KSC which would be developed to Level 8 during this module. These should be mostly Skills and Competences. However, Knowledge learning outcomes should also be included when the knowledge normally acquired during Level 7 programmes is insufficient for the development of the skills and competences to level 8. The KSC codes from the 'European Guidelines on the MPE' should be inserted for easy reference.	**GENERIC SKILLS** 1. Demonstrate a systematic understanding of a field of study and mastery of the skills and methods of research associated with that field. 5. Apply the acquired knowledge and understanding in different contexts and to innovate. 7. Make a contribution through original research that extends the frontier of knowledge some of which merits national or international refereed publication. 8. Demonstrate critical analysis, evaluation and synthesis of new and complex ideas. 10. Promote within professional contexts, technological, social or cultural advancement in a knowledge based society. **KSC FOR THE MPE AS PHYSICAL SCIENTIST** K43. Explain the basic principles of modelling and simulation. S2. Communicate clearly results to peers (in the form of notes, resumes, reports, poster, article, oral presentation) at local and international meetings and for research journals. C2. Assume responsibility to autonomously: - Realize the research objectives by integrating and applying knowledge and skills. - Communicate clearly results to peers (in the form of notes, resumes, reports, poster, journal/conference article, oral presentation) at local and international meetings and for research journals. - Defend results in front of peers.

	KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE): K138. Explain the importance of ongoing horizon scanning for new and emerging technologies. K140. Discuss the opportunities for innovation in own area of medical physics practice. S29. Use appropriate physical/software test objects/phantoms, data acquisition protocols, data recording forms, national/European/international protocols to measure the performance indicators of medical devices in own area of medical physics, assess deviations from acceptable values (as indicated by manufacturer and international/European/national standard setting bodies), evaluate the relevance of deviations for clinical practice and suggest actions for restoring default performance. S52. Handle and analyze medical images including the extraction of parametric data/images. C45. Take responsibility for semi-quantitative and quantitative data for clinical application. **KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY** K15. For each imaging modality, explain in detail the application of the following concepts/techniques for the improvement of the diagnostic value of medical images: reconstruction algorithms, image processing, image display, image visualisation, quantitative image analysis, computer aided diagnosis, vision and perception, image registration. K28. Define and explain the effect of variation of the following performance indicators on image quality in projection x-ray imaging (spatial resolution, contrast resolution, contrast to noise ratio, point spread function, modulation transfer function, noise power spectrum, detective quantum efficiency, noise equivalent quanta). K84. Explain how medical devices/ ionizing radiations and other physical agents are used for the solution of clinical problems in own area of medical physics practice. K137. Define innovation as the development of new devices (including software), modification of existing devices (including software) and the development of new techniques using devices for the solution of hitherto unresolved clinical problems. S2. For each modality predict the effect on image quality and diagnostic accuracy when changing scanning and reconstruction parameters. S11. Use modelling and simulation software (e.g. Matlab, SimuLink) to solve problems in the processing of imaging data. S14. For each imaging modality, select appropriate phantoms/phantom materials for dosimetry. S25. Evaluate imaging device performance for each imaging modality, from the measurement of suitable performance indicators using suitable test objects / phantoms. S34. For each imaging modality, apply the theory of image formation for the analysis and optimization of clinical acquisition protocols. S35. For each imaging modality, manipulate acquisition parameters (e.g., tube voltage, filtration, contour filters, tube current, exposure

	time, field size, magnification in projection x-ray imaging) to optimize image quality and patient dose. S36. For each imaging modality, explain the effect of operator selectable parameters on image quality and hence clinical utility. C1. Manage the conduct of experimental work autonomously and in a safe manner. C19. For each imaging modality, give advice regarding the adjustment of protocols to the needs of particular clients in studies which are complex, unusual, beyond-protocol and non-predictable. C23. Supervise image reconstruction and image handling procedures.
***SECONDARY KSC* targeted in *this* module** (EQF Level 8) These are the KSC that are included in the module but would be given less attention owing to time constraints. Please insert the KSC code from the 'European Guidelines on the MPE' project KSC Inventory.	**KSC FOR THE MPE AS PHYSICAL SCIENTIST** K26. Describe and explain at a basic level the following: temporal/frequency domain representation of signals, Fourier transform, statistical description of signals, power spectral density, autocorrelation function, sample (discrete) signals, delta function and its Fourier transform, Fourier transform of discrete signal (DFT), the FFT, the effect of finite sample intervals, linear processors, impulse response, convolution integral and theorem, various types of filters used in the processing of medical signals. S1. Manage the acquisition, editing, analysis, interpretation, presentation, and reporting of measurement data. **KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE)** K93. Understand the nature of anatomical/ pathological medical images as the visualization of the 3D distribution of physical variables. K132. Apply research methodologies and statistical techniques used at the interface between physical and biomedical science in clinical trials involving medical devices and/or ionizing radiations and other physical agents. K135. Describe the fundamentals and design models of clinical trials in own area of medical physics practice. K137. Define innovation as the development of new devices (including software), modification of existing devices (including software) and the development of new techniques using devices for the solution of hitherto unresolved clinical problems. K139. Describe the methodology of horizon scanning for new and emerging technologies. S35. Design and test physical and technical methods for quality control of devices in own area of medical physics practice. S53. Set up devices, experiments and protocols for the measurement of physical variables relevant to clinical practice. S78. Apply the methodology of horizon scanning (including listing of specific information sources) for new and emerging technologies to own area of medical physics practice. C44. Advise physician in image interpretation and quantification when appropriate. C82. Take responsibility for the development of new devices (including software) and modification of existing devices (including software), including their implementation and evaluation in response to clinical needs in own area of medical physics practice.

	C83. Take responsibility for legal issues involved in the development of medical devices (including software) in own area of medical physics practice. **KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY** K4. Explain in detail the principles of image quality measurement: linear systems theory, types of contrast (subject, image and display), unsharpness (LSR, PSF, LSF, MTF), lag, noise (including sources, noise power spectra, effect of lag on noise, noise propagation in image subtraction), SNR (including Rose model, Wagner's taxonomy, CNR, relation to dose, NEQ, DQE, NPS etc). K5. Explain inverse problem mathematical techniques used in image reconstruction (including both convolution and iterative methods and the advantages and disadvantages of each). K8. Explain the principles and methods of image post-processing including knowledge based image analysis, pattern theory, deterministic image processing and feature enhancement, image segmentation, image registration and co-registration / fusion. K9. Discuss the limitations of image post-processing. K10. For each imaging modality, define and explain in detail and quantitatively the physical property / properties of tissues which the device measures and images, including any variables impacting the value of these properties and associated tissue contrast (e.g., attenuation coefficient for CT which is dependent on beam energy/kV, tissue contrast in CT dependent on kV). K14. For each imaging modality, explain the relationship between target image quality outcomes and imaging device performance indicators. K22. For each imaging modality, explain device design variables, which impact device performance indicators (e.g., focal spot size in the case of x-ray imaging). K23. For each imaging modality, list and explain user controlled variables/settings and their impact on image quality/diagnostic efficacy and patient risk. K24. For each imaging modality, explain strengths and limitations and their impact on image quality / diagnostic efficacy (including any artefacts). K25. For each imaging modality, explain in detail acquisition protocols, pre-processing of image data, image reconstruction principles, post-processing of images. K26. For each imaging modality, describe and explain differences in device design and their effects on image quality and patient safety for dedicated devices (e.g., mammography, dental systems for projection x-ray imaging). K56. Explain the meaning of justification and optimization as applied to medical imaging practices. K58. For each imaging modality, list and explain in detail and whenever possible quantitatively protocol design variables (e.g., appropriate device settings, accessories, safety procedures, patient instructions) which impact patient safety and optimization of practices, procedures and acquisition protocols. K89. Explain the uses of medical imaging in diagnosis and therapy. K90. Interpret anatomical and functional 2D/3D images from the various modalities and recognise specific anatomical, functional and pathological features. K91. Describe the various clinical applications of each imaging modality and their significance for patient management.

	K93. Understand the nature of anatomical/ pathological medical images as the visualization of the 3D distribution of physical variables. S1. For each modality, operate imaging devices at the level necessary for give advice on optimization of imaging protocols, quality control, image quality manipulation, and carry out research when the available evidence for advice is not sufficient. S2. For each modality predict the effect on image quality and diagnostic accuracy when changing scanning and reconstruction parameters. S3. Manipulate acquisition parameters for all forms of projection x-ray imaging devices (e.g., kV, filtration, mAs, sensitivity ('speed'), collimation, magnification, SID, SSD, frame rate, screening time, manual/AED modes, compression), explain the effect on image quality and relevant patient dose quantities (and occupational dose particularly when this is correlated with patient dose) and relevance to specific clinical studies. S37. Apply theory of image reconstruction and post-processing to achieve optimal image quality for a specific clinical task. S38. For each imaging modality, assess imaging device performance levels requirements and scanning settings for specific clinical tasks. C13. Advise on the purchase of the most appropriate image modality / device model for a specific clinical application. C18. Apply the theory of image formation to advise on the selection of the most appropriate imaging modality. C19. For each imaging modality, give advice regarding the adjustment of protocols to the needs of particular clients in studies which are complex, unusual, beyond-protocol and non-predictable. C21. For each imaging modality, give advice on the different types of processing of images for specific clinical applications. C22. For each imaging modality, advise on routine and advanced visualisation techniques. C23. Supervise image reconstruction and image handling procedures.
***NEW KSC* which are NOT** INCLUDED in the 'Inventory of Learning Outcomes for the MPE in Europe'.	

OUTLINE TEACHING PLAN **Final detailed teaching plan to be delivered to the QAC electronically 30 days before the start of the online phase of the module**	
Online phase	Introduction to anthropomorphic phantoms ○ Overview ○ Definition for anthropomorphic phantoms ○ Classification of anthropomorphic phantoms ○ Areas of applications of anthropomorphic phantoms Design and composition of anthropomorphic phantoms ○ Overview ○ Components of anthropomorphic physical phantoms ○ Physical anthropomorphic phantoms and their software versions ○ Components of anthropomorphic computational phantoms ○ Examples of computational phantoms ○ References Software tools dedicated to research in x-ray imaging ○ Overview ○ ImageJ ○ Matlab ○ XRayImagingSimulator ○ BreastSimulator ○ FDKR ○ References Breast simulator ○ Basics - Breast Design ○ Basics - Mammography Simulation ○ Creation of Breast Computational Model - video tutorial ○ Breast Model Visualisation - video tutorial ○ Create Breast model with abnormality - video tutorial

	○ Image Simulation - video tutorial ○ Example: Small Breast Model - video tutorial ○ References XRAYImagingSimulator ○ Background ○ Create computational phantom – video tutorial ○ Image Formation - video tutorial ○ Examples ○ References Implementation of computational anthropomorphic phantoms (the case of breast) ○ Overview ○ Creation of a breast phantom. Goals ○ Creation of a breast phantom. Anatomy and Radiological Appearance ○ Creation of a breast phantom. Components ○ Creation of a breast phantom - in practice ○ References Applications of anthropomorphic phantoms ○ Overview ○ Applications of anthropomorphic phantoms in optimising the parameters of an existing imaging modality ○ Applications of anthropomorphic phantoms for design and evaluation of advanced x-ray imaging techniques ○ Applications of anthropomorphic phantoms for assessing the limitations of an x-ray imaging modality ○ Applications of anthropomorphic phantoms for design and evaluation of a physical phantom ○ References Computational anthropomorphic phantoms as prototypes of physical objects ○ Methods for manufacturing ○ Applications ○ References
Face-to- Face Phase	**Monday 07/09/2015** 09:15-10:00 Introduction to Anthropomorphic Phantoms (AP) *lecture & demos*

	10:15-11:00 Design and composition of anthropomorphic phantoms	*lecture*
	11:15-12:00 Design and composition of anthropomorphic phantoms	*lecture & demos*
	12:00-13:15 *lunch*	
	13:15-14:00 Design and Composition of Anthropomorphic Phantoms	*invited lecture, H Bosmans*
	14:15-15:00 Software tools dedicated to XRAYImagingResearch	*lecture & demos*
	15:15-16:00 Hands on implementation of computational anthropomorphic phantoms	*practical work*
	16:15-17:00 Hands on implementation of computational anthropomorphic phantoms	*practical work*
	Tuesday 8/09/2015	
	09:15-10:00 Application of AP for optimising and development of a clinical protocol	*invited lecture, H Bosmans*
	10:15-11:00 Application of AP for optimising and development of a clinical protocol	*demo, discussions*
	11:15-12:00 Application of AP for optimising breast tomosynthesis	*invited lecture, I. Sechopoulos*
	12:00-13:15 *lunch*	
	13:15-14:00 Application of AP for optimising breast tomosynthesis	*practical work*
	14:15-15:00 Application of AP for optimising breast tomosynthesis	*practical work, discussions*
	15:15-16:00 Application of AP for assessing the limitations of an imaging modality	*invited lecture, A. MacKenzie*
	16:15-17:00 Application of AP for assessing the limitations of an imaging modality	*demo & practical*
	Wednesday 9/09/2015	
	09:15-10:00 Application of AP for assessing the limitations of an imaging modality	*discussions, brainstorming*
	10:15-11:00 Application of AP for assessing the limitations of an imaging modality	*introduction to clinical case*
	11:00-11.30 *transport to hospital*	
	11:30-13:15 Application of AP for assessing the limitations of an imaging modality	*practical work*
	13:15-14.30 *lunch & transport to university*	
	15:15-16:00 Applications of AP in optimising the parameters of an existing imaging modality	*practical work*
	16:15-17:00 Applications of AP in optimising the parameters of an existing imaging modality	*practical work*
	Thursday 10/09/2015	
	09:15-10:00 Applications of AP for design and evaluation of advanced x-ray imaging techniques	*lecture, demos*

	10:15-11:00 Applications of AP for design and evaluation of advanced x-ray imaging techniques *invited lecture, A. Taibi* 11:15-12:00 Applications of AP for design and evaluation of advanced x-ray imaging techniques *practical work* 12:00-13:15 *lunch* 13:15-14:00 Applications of AP for design and evaluation of advanced x-ray imaging techniques *practical work* 14:15-15:00 Applications of anthropomorphic phantoms for development and testing of image enhancement techniques *lecture & demos* 15:15-16:00 Applications of anthropomorphic phantoms for development and testing of image enhancement techniques *demo & practical* 16:15-17:00 Applications of anthropomorphic phantoms for development and testing of image enhancement techniques *practical work* **Friday 11/09/2015** 09:15-10:00 Applications of anthropomorphic phantoms for development and testing of image reconstruction techniques *lecture & demos* 10:15-11:00 Applications of anthropomorphic phantoms for development and testing of image reconstruction techniques *lecture & demos* 11:15-12:00 Applications of anthropomorphic phantoms for development and testing of image reconstruction techniques *practical work* 12:00-13:15 *lunch* 13:15-14:00 Computational Anthropomorphic Phantoms as Prototypes of Physical Objects *lecture* 14:15-15:00 Computational Anthropomorphic Phantoms as Prototypes of Physical Objects *lecture* 15:15-16:00 Computational Anthropomorphic Phantoms as Prototypes of Physical Objects *demos, brainstorming* 16:15-17:00 Concluding remarks *discussion, brainstorming* **Saturday 12/09/2015** Free day **Sunday 13/09/2015** 09:00-10:00 written exam 10:30-13:30 presentation of work projects

READING LIST (APA format) Final List to be delivered to the QAC electronically 30 days before the start of the online phase of the module	
Required Pre-Module Reading list	
Required Within Module Reading list	
Suggested Post-Module Reading list	

TWO EXEMPLAR ASSESSMENT QUESTIONS To be delivered to the QAC electronically 30 days before the start of the online phase of the module	
Question 1	
Question 2	

EFOMP ACCREDITATION

To be delivered to the QAC electronically 30 days before the start of the online phase of the module

EFOMP accreditation certificate stating that the 'The module is appropriate for preparing Clinically Qualified Medical Physicists to achieve Medical Physics Expert status in Diagnostic and Interventional Radiology'

Please scan and paste a copy of the EFOMP accreditation certificate here.