The Royal College of Radiologists

FIRST EXAMINATION FOR THE FELLOWSHIP IN CLINICAL RADIOLOGY

Curriculum and Information: General

1 INTRODUCTION

1.1 The First Examination for the Fellowship in Clinical Radiology comprises two modules: Physics and Anatomy.

1.2 The purpose of the curriculum is to provide those undertaking specialty training in clinical radiology with appropriate knowledge of the physical principles that underpin diagnostic medical imaging and of the anatomy needed to perform and interpret radiological studies. When linked with other training in clinical radiology, this will lead to the safe and effective application of diagnostic imaging for the benefit of patients.

1.3 It is intended that the curriculum should be delivered during the first year of specialty training. This is expected to take about 40-45 hours of formal physics teaching and 30 hours of focussed anatomy teaching, over a period of about six months. This should be supplemented by practical training and private study of material recommended by trainers.

1.4 Assessment is in the form of the First FRCR Examination, which is held three times a year. The format of the assessment is different for each of the two modules and details of each are given in the relevant syllabus component later in this document. The two modules will be scheduled so that both may be attempted at the same sitting, although not necessarily at the same venue.

1.5 The curriculum has been developed by the Physics Working Group and Anatomy Working Group, and agreed by the Fellowship Examining Board and the Education Board of the Faculty of Clinical Radiology of the Royal College of Radiologists. It has been approved by the Postgraduate Medical Education and Training Board (PMETB) as an integral and mandatory component of specialty training in clinical radiology. It is kept under review and will be revised as appropriate.

1.6 The curriculum is presented in two separate syllabus components, one for each of Physics and Anatomy. These are laid out later in this document, along with the aims and learning objectives for each, and details of the assessment for each of the modules.

2 EXAMINATION STRUCTURE

2.1 The First FRCR Examination is held three times a year: normally in March, June and September. Each of the two modules is held at each sitting.

2.2 There is no limit on the number of times that a candidate may attempt either the examination overall or either of the modules. A candidate may attempt the modules at the same sitting or at separate sittings and may pass them either together or separately in any order. Once a pass has been obtained in a module there is no requirement to resit it. A candidate will be deemed to have achieved overall success at the First FRCR Examination once both modules have been passed.

2.3 No minimum period of clinical experience or clinical radiology training needs to have been completed in order to enter the examination. No confirmation of course attendance is required. Candidates undergoing specialty training in the UK require the signature of their training programme director on their application form each time they attempt the examination in order to confirm that the number and combination of modules to be taken are appropriate.

2.4 Candidates who attempted the First FRCR Examination in any of its previous formats without achieving success but without reaching the attempt limit (ie fewer than four attempts prior to the Winter 2002 sitting and/or fewer than three attempts between the Winter 2002 and Spring 2009 sittings) are permitted to enter the current format examination.

2.5 Candidates who reached the attempt limit for a previous format of the examination without achieving success (ie four attempts prior to the Winter 2002 sitting or three attempts between the Winter 2002 and Spring 2009 sittings) are not permitted to enter the current format examination.

2.6 In considering the eligibility of candidates who attempted the First FRCR Examination prior to the Winter 2002 sitting, attempts made at examinations that granted exemption from it will be taken into account.

2.7 No exemption is granted from the First FRCR Examination on the basis of success in any other examination.

Curriculum and Information: Physics

3 INTRODUCTION

3.1 The purpose of the curriculum is to provide those undertaking specialty training in clinical radiology with appropriate knowledge of the physical principles that underpin diagnostic medical imaging. When linked with other training in clinical radiology, this should lead to the safe and effective application of diagnostic imaging for the benefit of patients.

3.2 It is intended that the curriculum should be delivered during the first year of specialty training. This is expected to take about 40-45 hours of formal physics teaching, during the early months of specialty training, supplemented by practical training and private study of material recommended by trainers. Basic knowledge of physics and mathematics is assumed.

3.3 Assessment is in the form of a written multiple choice question (MCQ) paper. Further detail is given in Section 7 of this document and in the "Guidance Notes for Candidates", which are published on the College's website: www.rcr.ac.uk.

4 AIMS OF THE CURRICULUM

4.1 Provide appropriate knowledge of the physical principles that underpin the following diagnostic medical imaging modalities: planar (projection) x-radiography, x-ray fluoroscopy, x-ray computed tomography (CT), ultrasound imaging, magnetic resonance imaging (MRI), planar (projection) radionuclide imaging, single photon emission computed tomography (SPECT) and positron emission tomography (PET).

4.2 Describe how the concepts of risk, safety and quality apply in these imaging modalities including the responsibilities of individuals and organisations.

4.3 Provide sufficient understanding of the principles underlying each imaging modality to enable selection of the most appropriate modality for a particular clinical situation, to select the optimal operating factors, to interpret the images produced, to communicate the results and to discuss the complete imaging process with professional colleagues.

4.4 Assist trainees to satisfy the requirements for adequate training in order to carry out professional roles in medical diagnostic imaging as specified by UK legislation and guidance.

5 LEARNING OBJECTIVES

Those who have followed the curriculum should be able to:

5.1 Describe the structure and properties of matter, the phenomena of radioactivity and magnetism, the nature of ionising radiation, radiofrequency radiation and ultrasound and how they interact with matter.

5.2 Distinguish between different types of diagnostic medical image and understand how such images are created, reconstructed, processed, transmitted, stored and displayed.

5.3 Describe the construction and function of medical imaging equipment including the radiation or ultrasound source, image-forming components and image or signal receptor.

5.4 Indicate how imaging equipment is operated and describe the imaging techniques that are performed with such equipment.

5.5 Identify the type of information contained in images from different modalities.

5.6 Distinguish between different indices of image quality, explain how they are inter-related and indicate how they are affected by changing the operating factors of imaging equipment.

5.7 Identify agents that are used to enhance image contrast and explain their action.

5.8 Explain how the performance of imaging equipment is measured and expressed.

5.9 Describe the principles of quality assurance and outline how quality control tests of imaging equipment are performed and interpreted.

5.10 Recognise artefacts in medical images and identify how they are removed or their impact is reduced.

5.11 Recognise the hazards and risks to patients, members of staff and members of the public associated with medical imaging and describe how their impact is reduced without compromising diagnostic image quality.

5.12 Identify the major pieces of UK legislation and guidance that affect the practice of medical imaging and interpret their requirements.

6 EXAMINATION SYLLABUS

The syllabus is intended as a guide and general indication to the breadth of the topics that may appear in the examination questions. It is not a teaching plan and the bullet points do not relate to equal amounts of study time. The syllabus should be studied to a depth sufficient to allow the learning objectives in Section 5 above to be achieved.

6.1 Principles of medical diagnostic imaging

- Projection (planar) and tomographic images
- Analogue and digital images
- Structure of digital images

- Digital image processing, fusion, transmission and storage
- Display and viewing of analogue and digital images
- Picture Archiving and Communications Systems (PACS)
- Quality assurance

6.2 **Common themes for all imaging modalities**

- Image formation
- Image quality - contrast, noise, contrast resolution and spatial resolution
- Contrast agents
- Image processing and analysis
- Equipment performance measurement, test objects and quality control
- Image artefacts
- Hazards, risks and safety

6.3 **Matter and radiation**

- Structure of matter, the atom and the nucleus
- Nature and properties of charged particle and electromagnetic radiation
- Interaction of electrons with matter
- Production of x-rays
- Interaction of high energy photons with matter
- Filtration of x-ray beams
- Electron energy in solids
- Luminescence

6.4 **Ionising radiation dose**

- Absorbed dose and kinetic energy released to matter
- Effects of ionising radiation on living tissue
- Equivalent dose and effective dose
- Radiation risk
- Population dose from natural and artificial sources

6.5 **Radiography with x-rays**

- Construction, function and operation of computed and digital radiographic systems
- X-ray tube and x-ray beam
- Image receptors for computed and digital radiography
- Scatter rejection
- Contrast media – iodine, barium and air
- Dual energy radiography
- Film-screen radiography
- Mammography
- Radiographic tomography and tomosynthesis

6.6 **Fluoroscopy with x-rays**

- Construction, function and operation of a fluoroscopy system
- Image receptor – image intensifier and flat panel detector
- Scatter rejection
- Automatic brightness control
- Image digitisation
- Angiography with contrast media, including digital subtraction techniques

6.7 **Safety in radiography and fluoroscopy with x-rays**

- Radiation detectors and dose meters
- Measurement of absorbed dose and dose rate in air
- Estimation of patient absorbed dose
- Typical dose-area products, entrance surface doses and effective doses in radiography and fluoroscopy
- Detector dose indicators
- Factors affecting radiation dose
- Time, distance and shielding for dose reduction
- Children and pregnant patients
- Estimation and control of radiation dose to staff and members of the public
- Operational dose quantities
- Personal dosimetry
- Pregnant staff

6.8 **Radioactivity**

- Nuclear stability
- Mechanisms of radioactive transformation
- Nuclear energy states and gamma emission
- Activity and radioactive decay
- Natural radioactivity
- Artificial radionuclides and their production
- Radiopharmaceuticals and their production

6.9 **Planar radionuclide imaging**

- Construction, function and operation of a digital gamma camera
- Imaging collimators
- Image receptor – scintillation detector
- Scatter rejection
- Static, whole-body, dynamic and gated imaging

6.10 **Safety in planar radionuclide imaging**

- Activity measurement with radionuclide calibrator
- Estimation of patient absorbed dose
- Typical activities and effective doses
- Factors affecting radiation dose
- Time, distance and shielding for dose reduction
- Children and conception, pregnancy and breast-feeding in patients
- Estimation and control of radiation dose to staff and members of the public
- Pregnant staff
- Contamination and environmental dose rate monitoring
- Storage, handling and transportation of radioactive substances
- Storage and disposal of radioactive waste

6.11 **UK framework for ionising radiation protection**

- Hierarchy of recommendations, legislation and guidance
- Justification, optimisation and dose limitation
- Ionising Radiations Regulations 1999 and Approved Code of Practice
- Risk assessment, restriction of exposure and dose monitoring
- Radiation Protection Adviser and Radiation Protection Supervisor
- Local Rules and work procedures

- Designation of working areas and classification of workers
- Dose limits and dose constraints
- Comforters and carers
- Ionising Radiation (Medical Exposure) Regulations 2000, Notes on Good Practice and 2006 amendment
- Duty holders and their training and responsibilities
- Employer's procedures
- Diagnostic reference levels
- Exposures for research, health screening and medico-legal purposes
- Medicines (Administration of Radioactive Substances) Regulations 1978 and 1995 and 2006 amendments
- Administration of Radioactive Substances Advisory Committee and Notes for Guidance
- Radioactive Substances Act 1993
- Registration to hold radioactive substances
- Authorisation to store and dispose of radioactive waste
- Medical and Dental Guidance Notes
- Notification and reporting of radiation incidents

6.12 **Tomographic reconstruction**

- Angular and linear sampling of projection data
- Filtered back-projection and reconstruction filters
- Iterative reconstruction

6.13 **X-ray computed tomography**

- Construction, function and operation of a CT scanner
- Helical and multi-slice scanners
- Image reconstruction
- CT angiography, CT fluoroscopy and gated imaging
- Radiation dose to patients, staff and the public
- Radiation safety and factors affecting radiation dose

6.14 **Single photon emission computed tomography**

- Construction, function and operation of a rotating multi-head gamma camera
- Image reconstruction
- SPECT/CT
- Radiation safety and factors affecting radiation dose
- Typical activities and effective doses to patients, staff and the public

6.15 **Positron emission tomography**

- Construction, function and operation of a multi-detector ring system
- 2D and 3D acquisition
- Image reconstruction
- PET/CT
- Radiation safety and factors affecting radiation dose
- Typical activities and effective doses to patients, staff and the public

6.16 **Nuclear magnetic resonance**

- Nuclear spin angular momentum and nuclear magnetic moment
- Bulk magnetisation and the effect of magnetic field strength
- Precession in a magnetic field and the Larmor equation

- Resonance with radiofrequency pulses
- Relaxation mechanisms and relaxation times
- Free induction decay signal

6.17 **Magnetic resonance imaging**

- Construction, function and operation of a superconducting MRI scanner
- Permanent and resistive magnets
- Radiofrequency receiver coils
- Spin-echo pulse sequence
- Spatial localisation of the signal
- K-space, image acquisition and image reconstruction
- Multi-echo, fast spin-echo and single shot techniques
- Gradient echo imaging – basic spoiled and non-spoiled techniques
- Tissue suppression methods – short TI inversion recovery (STIR), fluid attenuated inversion recovery (FLAIR) and fat saturation
- Basic principles of diffusion techniques
- Standard gadolinium extracellular space contrast agents
- MR angiography
- Spatial misregistration, chemical shift, susceptibility, motion, flow and other artefacts

6.18 **Safety in magnetic resonance imaging**

- Static magnetic field – projectiles, induced voltage, implants
- Fringe field and controlled area
- Time-varying gradient fields – eddy currents, stimulation, implanted devices, acoustic noise
- Radiofrequency fields – specific absorption rate, heating
- Safety of patients, staff and members of the public
- Pregnant patients
- Shielding and imaging room design
- Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use

6.19 **Physics of ultrasound**

- Nature and properties of ultrasound
- Propagation and interaction of ultrasound in matter
- Scattering of ultrasound waves
- Piezoelectric effect
- Design and construction of ultrasound transducers
- Continuous and pulsed wave ultrasound
- Beam shape from a single transducer and an annular array
- The Doppler effect

6.20 **Ultrasound imaging**

- A-mode and B-mode imaging
- Time-gain compensation
- Construction, function and operation of a real-time B-mode scanner
- Image acquisition and reconstruction
- M-mode
- Microbubble and particle suspension contrast agents
- Harmonic imaging
- Measurement of flow with continuous and pulsed Doppler ultrasound

- Duplex scanners
- Colour-flow and power Doppler imaging

6.21 **Safety in ultrasound imaging**

- Physical effects - heating, streaming, cavitation and mechanical damage
- Intensity and energy limits
- Thermal and mechanical indices
- Measurement of power output
- Safety of patients, staff and members of the public
- Safety guidance

7 ASSESSMENT

7.1 The examination for the Physics module comprises a single paper of 40 multiple choice questions (MCQs) and is of two hours in duration.

7.2 The examination is held at five UK venues (Birmingham, Bristol, Edinburgh, London and Manchester) and three non-UK venues (Dublin, Hong Kong and Singapore).

7.3 The standard for success is determined at each sitting of the examination based on the difficulty of the questions used and so may vary between sittings.

7.4 Further details about the examination can be found in the "Guidance Notes for Candidates", which are published on the College's website (www.rcr.ac.uk) and sent to all candidates when their application is accepted.

Curriculum and Information: Anatomy

8 INTRODUCTION

8.1 The purpose of the curriculum is to provide those undertaking specialty training in clinical radiology with appropriate knowledge of the anatomy needed to perform and interpret radiological studies. When linked to other training in clinical radiology, this will lead to the safe and effective application of diagnostic imaging for the benefit of patients.

8.2 It is intended that the curriculum should be delivered during the first year of specialty training. This is expected to take about 30 hours of focused anatomy teaching, over a period of about 6 months, supplemented by practical training and private study of material recommended by teachers. Basic knowledge of anatomy is assumed.

8.3 Assessment is in the form of an electronic image viewing session. Further detail is given in Section 12 of this document and in the "Guidance Notes for Candidates", which are published on the College's website: www.rcr.ac.uk.

8.4 A knowledge of radiological anatomy is fundamental to the study of radiology. It is intended that the First FRCR Examination is taken after only six months of clinical radiology training and the standard and level of anatomical knowledge tested and expected reflect this. The assessment is of knowledge of radiological anatomy – not surgical anatomy, surface anatomy or cadaveric anatomy – but applied anatomy that is relevant to clinical radiology.

9 AIMS OF THE CURRICULUM

9.1 Provide appropriate knowledge of the anatomy that underpins all radiological imaging including radiography, fluoroscopy, computed tomography (CT), ultrasound imaging and magnetic resonance imaging (MRI).

9.2 Provide sufficient understanding of the radiological anatomy that is visible on each imaging modality to perform and interpret studies including communicating the results and discussion with clinical colleagues.

10 LEARNING OBJECTIVES

Those who have followed the curriculum should be able to:

10.1 Describe and recognise the bony and soft tissue anatomy visible on radiographs, including common normal variants. This will include children of all ages.

10.2 Describe and recognise the radiological anatomy visible on CT, including multiplanar reformats. This will include solid organs such as the heart and lungs, bones, vessels and muscles.

10.3 Describe and recognise the radiological anatomy visible on ultrasound imaging, including first trimester antenatal ultrasound. This will include solid viscera such as the liver and spleen, bones, vessels, major ligaments and tendons. Endocavity ultrasound, such as transvaginal, transrectal and endoscopic ultrasound, will be excluded.

10.4 Describe and recognise the radiological anatomy of MRI, including solid viscera such as the brain and abdominal organs, bones, joints, muscles and vessels.

10.5 Describe and recognise the radiological anatomy of fluoroscopic studies of the gastro-intestinal, biliary, genito-urinary and vascular systems.

NB: Nuclear medicine, including positron emission tomography, is excluded from the anatomy curriculum.

11 EXAMINATION SYLLABUS

This syllabus is intended as a guide and general indication to the breadth of the topics that may appear in the examination questions. It is not a teaching plan and the bullet points do not relate to equal amounts of study time. The syllabus should be read in conjunction with the learning objectives in Section 10 above.

1 Head & Neck

1.1 *Brain*

- Ventricles and CSF spaces
- Arteries and venous sinuses
- Basal nuclei and major white matter tracts
- Cerebrum and cerebellum
- Cranial nerves
- Pituitary and juxtasellar structures

1.2 *Skull*

- Calvaria and base of skull

1.3 *Face and neck*

- Arteries and veins
- Sinuses
- Orbit and contents
- Facial skeleton
- Tongue and oral cavity
- Lymph node groups
- Larynx and pharynx
- Thyroid and parathyroid
- Salivary glands

2 Thorax

2.1 *Cardiac*

- Mediastinum, pericardium and lymph node groups
- Cardiac chambers, valves, arteries and veins
- Great vessels and azygos/hemi-azygos system

2.2 ***Bronchopulmonary***

- Trachea and major bronchi
- Pulmonary vasculature
- Pleura and fissures

2.3 ***Chest wall and diaphragm***

2.4 ***Breast and axilla***

3 Abdomen and Pelvis

3.1 ***Bowel***

- Oesophagus and stomach
- Duodenum, small bowel and appendix
- Colon, rectum and anus

3.2 ***Upper Abdominal Viscera***

- Liver segments and blood vessels
- Biliary tree and gall bladder
- Pancreas, adrenals and spleen

3.3 ***Abdominal wall***

3.4 ***Spaces and planes***

- Perirenal and pararenal spaces and fasciae
- Peritoneal reflections and spaces

3.5 ***Genitourinary tract***

- Kidneys and pelvicalyceal systems
- Ureters and bladder
- Prostate, seminal vesicles and urethra
- Testes and epididymides

3.6 ***Gynaecology***

- Ovaries and fallopian tubes
- Uterus and cervix
- Vagina

3.7 ***Vascular supply***

- Portal venous system
- Aorta and major branches
- IVC and tributaries

3.8 ***Lymph node groups***

4 Musculoskeletal system

4.1 ***Spine***

- Vertebrae, sacrum and joints
- Paraspinal muscles and ligaments
- Spinal cord, cauda equina and nerve roots

4.2 ***Upper Limb***

- Bones and joints, including shoulder
- Muscles and nerves
- Blood vessels

4.3 ***Lower Limb***

- Bones and joints, including pelvis
- Muscles and nerves
- Blood vessels

12 **ASSESSMENT**

12.1 The examination for the Anatomy module comprises an electronic image viewing session of 100 questions (20 images and five questions on each) and is of 1¼ hours in duration.

12.2 Initially, ie for the three sittings in 2010, the examination will only be held in London.

12.3 Additionally, for the three sittings in 2010, the examination will be available in Hong Kong and Singapore in paper format.

12.4 The introduction of additional UK venues and the adoption of an electronic format examination in Hong Kong and Singapore at a later stage are being explored.

12.5 The standard for success is determined at each sitting of the examination based on the difficulty of the questions used and so may vary between sittings. It is likely that more than one set of images and questions will be utilised at each sitting and the standard required for success may also vary between the sets of images and questions.

12.6 Further details about the examination can be found in the "Guidance Notes for Candidates", which are published on the College's website (www.rcr.ac.uk) and sent to all candidates when their application is accepted.

August 2009