IAEA
International Atomic Energy Agency

Clinical Training of Medical Physicists Specializing in Nuclear Medicine

VIENNA, 2011

TRAINING COURSE SERIES 50

CLINICAL TRAINING OF MEDICAL PHYSICISTS SPECIALIZING IN NUCLEAR MEDICINE

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TRAINING COURSE SERIES No. 50

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2011

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CLINICAL TRAINING OF MEDICAL PHYSICISTS SPECIALIZING IN NUCLEAR MEDICINE
IAEA, VIENNA, 2011
IAEA-TCS-50
ISSN 1018-5518

Printed by the IAEA in Austria
May 2011

FOREWORD

The application of radiation in human health, for both diagnosis and treatment of disease, is an important component of the work of the IAEA. The responsibility for the increasingly technical aspects of this work is undertaken by the medical physicist. To ensure good practice in this vital area, structured clinical training programmes are required to complement academic learning. This publication is intended to be a guide to the practical implementation of such a programme for nuclear medicine.

There is a general and growing awareness that radiation medicine is increasingly dependent on well trained medical physicists who are based in a clinical setting. However an analysis of the availability of medical physicists indicates a large shortfall of qualified and capable professionals. This is particularly evident in developing countries. While strategies to increase educational opportunities are critical to such countries, the need for guidance on structured clinical training was recognized by the members of the Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology (RCA) for the Asia–Pacific region. Consequently, a technical cooperation regional project (RAS6038) under the RCA programme was formulated to address this need in this region by developing suitable material and establishing its viability.

Development of a clinical training guide for medical physicists specialising in nuclear medicine was started in 2009 with the appointment of a core drafting committee of regional and international experts. The publication drew on the experience of clinical training in Australia, Croatia and Sweden and was moderated by physicists working in the Asian region. The present publication follows the approach of earlier IAEA publications in the Training Course Series, specifically Nos 37 and 47, Clinical Training of Medical Physicists Specializing in Radiation Oncology and Clinical Training of Medical Physicists Specializing in Diagnostic Radiology, respectively. This approach to clinical training has been successfully tested in Thailand, with three other Member States currently undergoing testing, and is believed to be generally applicable to the medical physics community in general.

The IAEA acknowledges the special contribution of the drafting committee under the chairmanship of R. Fulton (Australia), with K. Afroj Quadir, (Bangladesh), B. Axelsson (Sweden), T. Bokulic (Croatia), A. Krisanachinda (Thailand) and B. J. Thomas (Australia). The IAEA officers responsible for this publication were I. D. McLean and S. Palm of the Division of Human Health, and M.P. Dias of the Division for Asia and the Pacific, Department of Technical Cooperation.

EDITORIAL NOTE

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CONTENTS

1. INTRODUCTION

1.1.The need for physicists in nuclear medicine

Medical physicists fulfil an essential role in modern medicine. Medical physicists working in the field of nuclear medicine are specialised in that role and are generally called "Nuclear medicine physicists". They are part of an interdisciplinary team in the Nuclear Medicine Department dedicated to providing safe and effective diagnosis and treatment of disease using radioactive unsealed sources. Other members of the team include nuclear medicine physicians and nuclear medicine technologists.

The roles and responsibilities of the nuclear medicine physicist are diverse and demanding. They include dosimetry, image quality, optimization, research and teaching, radiation safety, quality assurance and equipment management. The nuclear medicine physicist's knowledge of the complex techniques and equipment involved in modern diagnosis and treatment of disease are essential to the safe and effective application of nuclear medicine procedures.

Nuclear medicine physicists apply their knowledge of mathematics, physics and technology to establish, implement and monitor processes which allow optimal diagnosis and treatment, taking account of the radiation protection of the patients and others [1]. Nuclear medicine physicists are responsible for ensuring that the equipment, systems and processes used in nuclear medicine will produce the desired diagnosis when they are applied correctly. They must be able to recognize common artefacts in clinical images and undertake remedial action to correct the problem. Nuclear medicine physicists recognize and understand the sources of error in nuclear medicine studies and are responsible for the validation of the techniques used.

They are also involved in the development, implementation, maintenance and quality control of the infrastructure (facilities, equipment & clinical computer systems) and new processes necessary for the provision of nuclear medicine. They are scientifically trained in the techniques for accurate measurement and numerical recording that underlie a proper quality control system for the equipment used in nuclear medicine.

The nuclear medicine physicist has the ability to critically assess faults, and assign tolerances, test frequencies and remedial action. The decision to hand over a piece of nuclear medicine equipment for clinical use after a repair which might affect the clinical accuracy of the equipment must be made by a nuclear medicine physicist. This may require a balanced judgment between the need to provide a service to patients and the need for diagnostic accuracy. It has been well documented that patient welfare can be severely compromised in the practice of nuclear medicine when proper quality assurance (QA) is not performed. Appropriate QA can only be implemented and practiced by adequately trained staff.

1.2.The need for structured and supervised clinical training of Medical Physicists specializing in Nuclear Medicine

The role of the medical physicist specialized in nuclear medicine is built on a foundation in university level general physics which then requires specialized knowledge and processes to understand the technical complexities of medical imaging. However to be clinically qualified to practice alone in a medical facility, the medical physics professional must have experience in a wide range situations and be able to make professional judgements, based on sound scientific principles and experience. To gain this ability the new graduate needs to be supervised by one or more senior competent medical physicists and to be extended through a structured training programme that ensures the widest possible set of relevant experiences.

While similar knowledge and training principles have existed for many years in other professions, such as medicine, it is only recently that this approach has been recognised as essential for medical physicists [2-4]. In summary a clinically qualified medical physicist specialized in nuclear medicine physics should have:

- A university degree in physics, engineering or equivalent physical science;
- Appropriate academic qualifications in medical physics (or equivalent) at the postgraduate level [5];
- At least two years (full time equivalent) structured and supervised clinical training[1] undertaken in a hospital[2].

Member States that do not have a master's program with the required content in place are strongly encouraged to formulate a strategy to achieve this.

It is emphasized that the holder of a university degree in medical physics without the required hospital training cannot be considered clinically qualified.

The above standard for the education and training of medical physicists should be recognised by the nationally responsible authority. The lack of recognition of medical physics standards is a problem common to almost all countries. However a national accreditation process (or certification), ideally through a professional organisation, is seen as vital in raising the standard of the practice of medical physics. The continuing professional development of the practicing medical physicist through short courses, conference attendance, access to the scientific literature etc. should then follow.

Postgraduate courses in medical physics at the Masters level are offered by many universities. To enrol in these courses, students are normally required to have completed an undergraduate (bachelor level) degree in physics or an acceptable alternative. These Master's courses are typically of 18–24 months duration and provide the graduate with knowledge of the physics and technology underpinning the practice of nuclear medicine, however in order to independently and safely perform the roles and responsibilities of a medical physicist a significant period of structured in-service clinical training is required.

The duration of this clinical training is agreed to be at least 24 months full time and can only be provided in a hospital with access to full nuclear medicine services[3] under the supervision of a medical physicist qualified in nuclear medicine. Hence the total time required for education and clinical training of a medical physicist is at least 4 years (2 years postgraduate university education plus at least 2 years clinical training) following completion of a bachelor degree in physics or acceptable alternative.

1.3.Why this programme?

While the shortage of clinically qualified medical physicists is a worldwide problem it is most acute in developing nations. One important reason for this is the migration of promising physics professionals from developing countries to more developed countries where the recognition of the medical physicists is better established. The introduction of a programme of clinical training to supplement academic qualifications has the dual purpose of providing

[1] The period of clinical training would include service delivery and research and development.
[2] A hospital or clinical centre approved for the purpose by the nationally responsible authority.
[3] The term 'full nuclear medicine services' will be defined by the nationally responsible authority to be consistent with the services available in the country.

skilled professionals for the developing country as well as providing standards that can be used to raise the recognition on medical physicists.

In an increasing number of countries Master level courses in medical physics are offered by universities. The clinical in-service training component however is in many cases missing. This has resulted in incomplete preparation of the medical physicists to practice independently as important aspects of training cannot be completed in the university setting. A structured in-service clinical training programme provides a better preparation for medical physicists to ensure that they are capable of independent, safe and effective practice. Such a programme should reduce the total time needed for medical physicists, referred to as residents in this programme, to reach clinical competence and also to prepare them to undertake the more advanced methodologies which are being rapidly introduced in nuclear medicine.

The resident medical physicist in this programme is expected to be an employee of a clinical facility or hospital with responsibility in a suitable nuclear medicine facility and would contribute to the routine duties of medical physicists within that department. This contribution would initially be in the role of an assistant but would, as the resident's level of knowledge and skills progressed, become more and more substantial. In the final 6-12 months of training the resident would make an independent contribution to many of the roles of the medical physicist, and require only limited supervision. Hence the investment of time and effort in training residents is repaid as they become more competent and increase their contribution back to the department.

The IAEA has a long history of involvement in medical physics education and training. This document has been recently developed as a guide to be used in the clinical training of the next generation of Medical Physicists specialising in Nuclear Medicine. This guide is a companion to a previous publications for the clinical training of medical physicists specializing in radiation oncology [6] and diagnostic radiology [7].

2. OBJECTIVE OF THE CLINICAL TRAINING PROGRAMME

The objective of the clinical training programme for Medical Physicists specialising in nuclear medicine is to produce an independent practitioner who is a lifelong learner and who can work unsupervised within a multi-disciplinary team at a safe and highly professional standard[4].

The clinical training programme is seeking to assist this objective through;

- Provision of this detailed guide to clinical training and appendices I–V;
- Provision of an implementation strategy to allow effective clinical training. Forming a basis for a national or regional qualification (education and clinical training) standard;
- Providing assistance to national bodies and departments to deliver the training programme through a pilot programme;
- Promoting quality improvement of the programme; and
- Strengthening of the national capacity to sustain such a clinical training programme after initial introduction.

[4] For more complete description see Appendix V, assessment objectives

3. ESSENTIAL REQUIREMENTS FOR IMPLEMENTATION OF THE CLINICAL TRAINING PROGRAMME[5].

3.1. Programme management

On the level of an individual resident, the concept of clinical training can be relatively simple. However as a programme begins to involve many individual residents spread over a number of medical facilities, it grows in complexity and importantly it also needs clear assessment standards which need to be established and maintained[6]. This calls for a defined management structure.

This structure would normally be most effective on a national level[7] and usually needs to be placed within an established body or institution (such as a professional body for example). Relatively few countries have developed structures for clinical training currently in place. To assist in cases with limited existing management structures and limited resources, external assistance is advocated.

3.1.1. National

The programme should be under the direction of a national authority such as the Ministry of Education, Ministry of Health, relevant professional body or the National Atomic Energy Authority. It will have overall responsibility for the programme and is referred to, in this publication, as the **National Responsible Authority**.

The National Responsible Authority provides **formal recognition** of the qualification "Nuclear Medicine Physicist" (or equivalent) and the requirements to become one.

In managing the programme the National Responsible Authority must:

- Establish a ***National Steering Committee*** to oversee the programme. The National Steering Committee is the working arm of the National Responsible Authority. The Committee comprises of representatives from the relevant professional body (where one exists) and other relevant interest groups and stake holders (such as Ministry of Health, Universities, Radiation protection authority, Allied professional societies etc.). It is highly recommended that representatives from the relevant professional body should form the majority of members. It is expected that the National Steering Committee will delegate its day to day responsibilities to the National Programme Coordinator.
- Appoint a National Programme Coordinator to oversee the implementation of the programme (appointment of several Programme Coordinators may be justified in large countries where regional coordination is necessary). The National Programme Coordinator should, ideally, be a person engaged in the practice of nuclear medicine physics. The Coordinator will normally report to the National Steering Committee.
- Ensure that the Professional Body sets the professional standards required to define competency, provides professional support for the programme and has overall responsible for the assessment processes. This may involve the forming of an assessment committee.

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[5] see Appendix III for more detail on this section
[6] See Appendix V Assessment criteria, page 161.
[7] Regional clinical training programmes might also be possible in some circumstances

- Establish a Support Group of individuals who agree to assist with Resident training. The support group may include nuclear medicine physicians, nuclear medicine physicists and personnel from educational institutions. Preferably one person external to the country should be a member of the support group.
- Ensure that the programme is financially viable. Ideally the employer and/or government authorities benefiting from the improvement in the medical physicist workforce resulting from the clinical training should contribute financially to the programme.

3.1.2. External

One form of external assistance involves the pilot testing of the clinical training programme in selected countries for a trial period of several years. For these pilot programmes an external management structure has been formed to coordinate external support and to oversee the general conduct of the programme. An external coordinator has been appointed by the RCA to work closely with the National Programme Coordinator and National Steering Committee to ensure the smooth operation and success of the programme. External experts may also be utilised to assist departments with aspects of the programme and to monitor standards of assessment.

3.2. Minimum recommended requirements for departments to undertake a clinical training programme

For a department to participate in the programme it must:

- Provide a resident with a supervisor who is experienced and clinically competent in nuclear medicine physics[8].
- Have (on-site) a specified range of nuclear medicine and dosimetry equipment with appropriate established QA processes. For some equipment a preparedness to rotate residents to other departments with that equipment is acceptable.
- Offer a significant range of nuclear medicine services and employ medical practitioners trained in nuclear medicine.
- Provide residents with access to textbooks and other relevant resources such as the internet.

4. ELEMENTS OF THE CLINICAL TRAINING PROGRAMME

Documents to assist countries in implementing a structured clinical training programme for nuclear medicine physicists have been developed. These are included as appendices to this text as seen below:

- Appendix I: A handbook for Residents in the programme;
- Appendix II: A handbook to assist clinical supervisors in the performance of their important role in this programme;
- Appendix III: An implementation manual to assist a country and departments with the introduction of the programme;

[8] In some situations it may be possible to utilize a form of remote supervision with the use of a suitable communication system.

- Appendix IV: A guide which is divided into modules and sub-modules relating to the essential elements of the roles and responsibilities of medical physicists specialising in nuclear medicine. Each sub-module contains suggested items of training to assist the resident in acquiring necessary knowledge and skills in the area;
- Appendix V: A guide to the assessment of competency in the areas of these sub-modules and other aspects of the programme;
- Appendix VI: Supplementary forms and documents.

APPENDIX I.
HANDBOOK FOR RESIDENTS

CONTENTS

ACKNOWLEDGEMENTS

This appendix has been based on the Handbook for Residents developed in New South Wales (NSW) for use in the Training, Education and Accreditation Programme (TEAP) of the ACPSEM for registrars in radiation oncology medical physics. The input of NSW Health is gratefully acknowledged.

I.1. INTRODUCTION

The shortage of clinically qualified medical physicists in all specialties of radiation medicine is a worldwide problem that is well recognised and is most acute in developing nations. The increasing complexity of both diagnostic and treatment equipment coupled with the raising of the expectations of good health care in all parts of the world, as well as the implementation of radiation safety standards, are contributing to worsen this shortage.

Resolution of this shortage can be approached by supporting existing medical physicists and by ensuring appropriate training for those seeking to enter the profession. The IAEA has a long history of involvement in medical physics education and clinical training and have participated in both aspects with the support of practicing medical physicists through workshops, training courses and fellowship programmes. More recently the RCA and the IAEA have committed to raising the standard of the next generation of medical physicists through educational and clinical training initiatives and support programmes.

The fundamental problem of providing competent medical physicists in a clinical environment cannot be fully realised until the education and clinical training of the entry practitioner is at a suitable standard.

The IAEA states that a clinically qualified medical physicist must have:

- a university degree in physics, engineering or equivalent physical science;
- appropriate academic qualifications in medical physics (or equivalent) at the postgraduate level;
- a minimum of two years (full time equivalent) structured clinical in-service training undertaken in a hospital.

This standard also states "It is emphasized that the holder of a university degree in medical physics without the required hospital training cannot be considered clinically qualified."

To partially address the problem of providing clinical training for the next generation of Medical Physicists specialising in Nuclear Medicine a Clinical Training Guide and other resources to assist in the implementation of a clinical training programme for residents has been developed. Persons undergoing training in this programme are referred to as Residents.

The current publication has been developed to assist Residents with their understanding of the nature of the programme as well as the roles and responsibilities that they and others have in ensuring optimum clinical training.

It is important that this publication is carefully read before commencing clinical training.

I.2. STRUCTURE OF THE CLINICAL TRAINING PROGRAMME

The structure and lines of communication within the RCA pilot of the clinical training programme are shown schematically in Fig. I.1. Following is a brief explanation of the roles of the some of the groups/persons indicated in Fig. I.1. Further details can be found in the publication Appendix III *Implementation guide*.

- The ***National Responsible Authority*** such as the relevant professional body, Ministry of Education, Ministry of Health or the National Atomic Energy Authority, has overall responsibility for the programme. It provides formal recognition of the qualification provided by the program. It will form a National Steering Committee and appoint a National Programme Coordinator. The National Responsible Authority will normally delegate authority to a National Steering Committee to oversee the program.
- The ***National Steering Committee*** is comprised of the Professional Body and representatives from relevant interest groups and stake holders. The National Steering Committee is responsible for maintaining standards in the programme by ensuring that guidelines for participation are strictly followed by Departments and Residents. It deals with complaints and appeals. It supervises the National Programme Coordinator.
- The ***Professional Body*** is responsible for setting the professional standards required to define competency and providing professional support for the programme. It would normally have overall responsibility for the assessment processes.
- The ***Clinical Supervisor*** is a suitably qualified and experienced medical physicist specialising in nuclear medicine who is working in the same department as the Resident. He or she has a pivotal role in ensuring the success of the clinical training of a Resident. See section 3.1 for more detail on the roles and responsibilities of the Clinical Supervisor.
- The ***Support Group*** is made up of individuals who agree to assist with Resident training. The support group may include nuclear medicine physicians, nuclear medicine physicists and personnel from educational institutions. Ideally, at least one person, external to the country, is also a member of the support group.

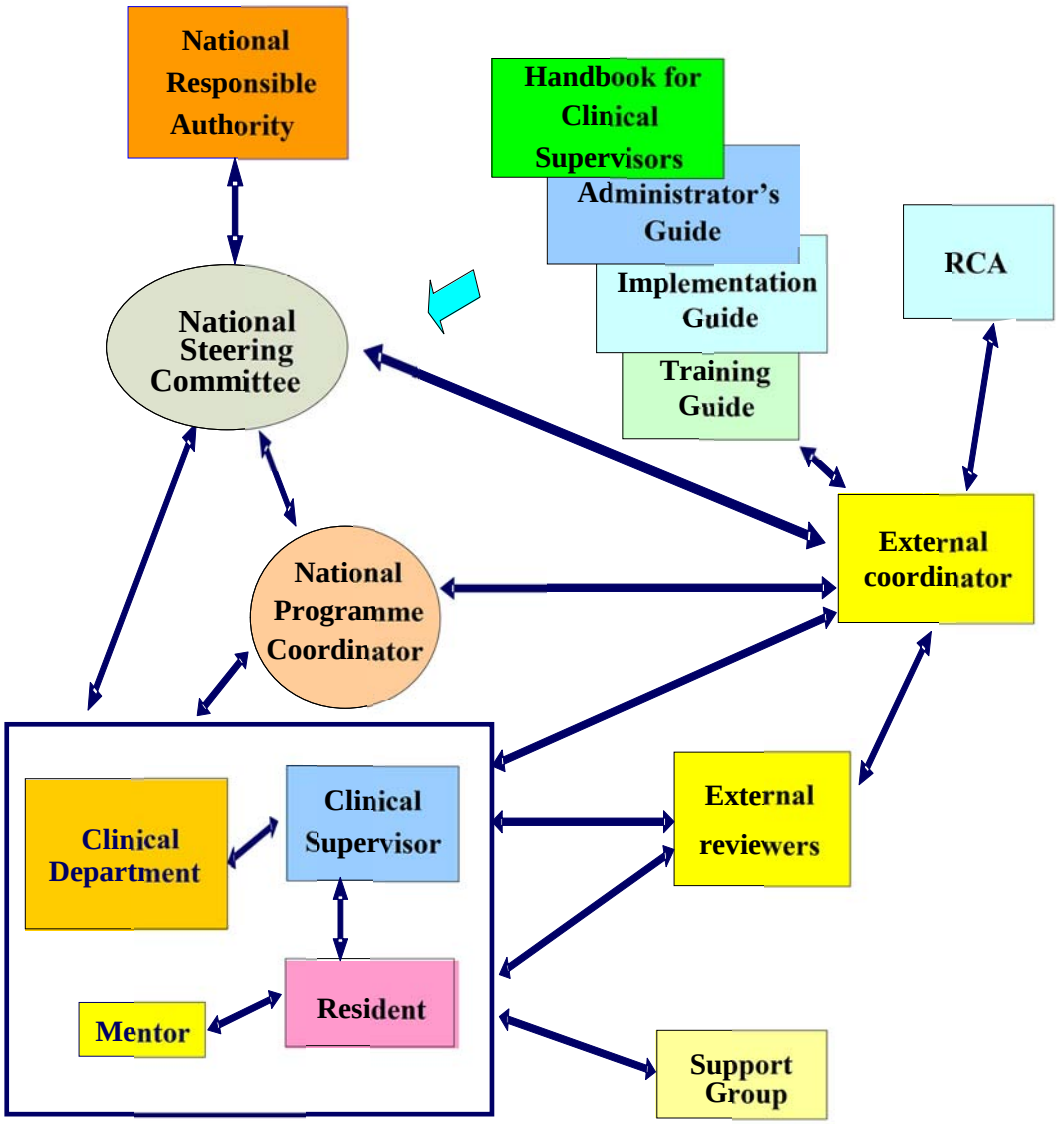

FIG. I.1. Schematic showing the management structure and lines of communication within the RCA pilot clinical training programme. Some lines of communication (e.g. department-resident) have been omitted for simplicity.

- The ***External Coordinator*** monitors the progress of Residents and the programme in general. He/she works closely with the National Programme Coordinator and National Steering Committee to ensure the smooth operation and success of the programme.
- The ***External Reviewers*** monitor the progress of individual Residents and review their work plan or items of assessment.

I.3. ROLES AND RESPONSIBILITIES OF RESIDENTS

Success of the clinical training programme relies on you, the Resident, undertaking self-directed study including, in consultation with the Clinical Supervisor, determining deadlines. You must also take individual responsibility for meeting those deadlines. Difficulty completing the programme is expected to be encountered when a Resident has low initiative and/or is slow to accept responsibility.

Termination of the clinical training position may be considered if you fail to meet the standards required in the programme following a period of supportive and corrective feedback and opportunity to improve.

Your responsibilities include:

- Meeting regularly with your Clinical Supervisor to discuss progress and to review deadlines.
- Accepting the supportive and corrective feedback provided by your Clinical Supervisor and other experienced medical physicists in your department. You need to accept this feedback in the spirit that it is provided, i.e. to assist in improving your performance in the programme.
- Maintaining necessary documentation. An important example is to ensure that your Clinical Supervisor "signs off" after completing a competency assessment. A second important example is keeping your portfolio up-to-date.
- Preparing in a thorough manner for all assessments required as part of the programme.
- Taking every opportunity to develop your knowledge and skills and, once acquired, maintaining the knowledge and skills.

I.4. ROLES AND RESPONSIBILITIES OF CLINICAL SUPERVISORS

The clinical supervisor's responsibilities include:

- Ensuring that the Resident is trained in all significant aspects of nuclear medicine physics by facilitating a structured training programme in keeping with the guide and with the scope of modules and assessment levels to be completed as determined by the National Steering Committee. Note that this does not mean that all the training is done by the supervisor. It is the responsibility of the supervisor to ensure that suitably qualified specialists undertake the training of the Resident in the various facets of the programme.
- Meeting regularly with the Resident to discuss progress (including reviewing deadlines) and to provide adequate supportive **and** corrective feedback to the Resident such as the level of competency achieved and competency achievements which have fallen behind. (Note: in this document a "meeting" may be face-to-face or by videoconference or other means as the circumstances allow or require.)
- Providing a six monthly report on the Resident's progress to the National Programme Coordinator.
- Ensuring that the Resident's clinical training and performance is monitored, documented, assessed and reported as required.
- Ensuring that the in-service clinical training is provided to a standard acceptable to the National Steering Committee and providing to the Resident support where required.
- Ensuring that the Resident is placed in other hospitals, where possible, for short periods to gain experience in techniques or the use of equipment not available in the Resident's own department.
- Ensuring that the Resident has sufficient opportunity to prepare for all assessments required as part of the programme.
- Facilitating external assessments of Residents during their training where possible.

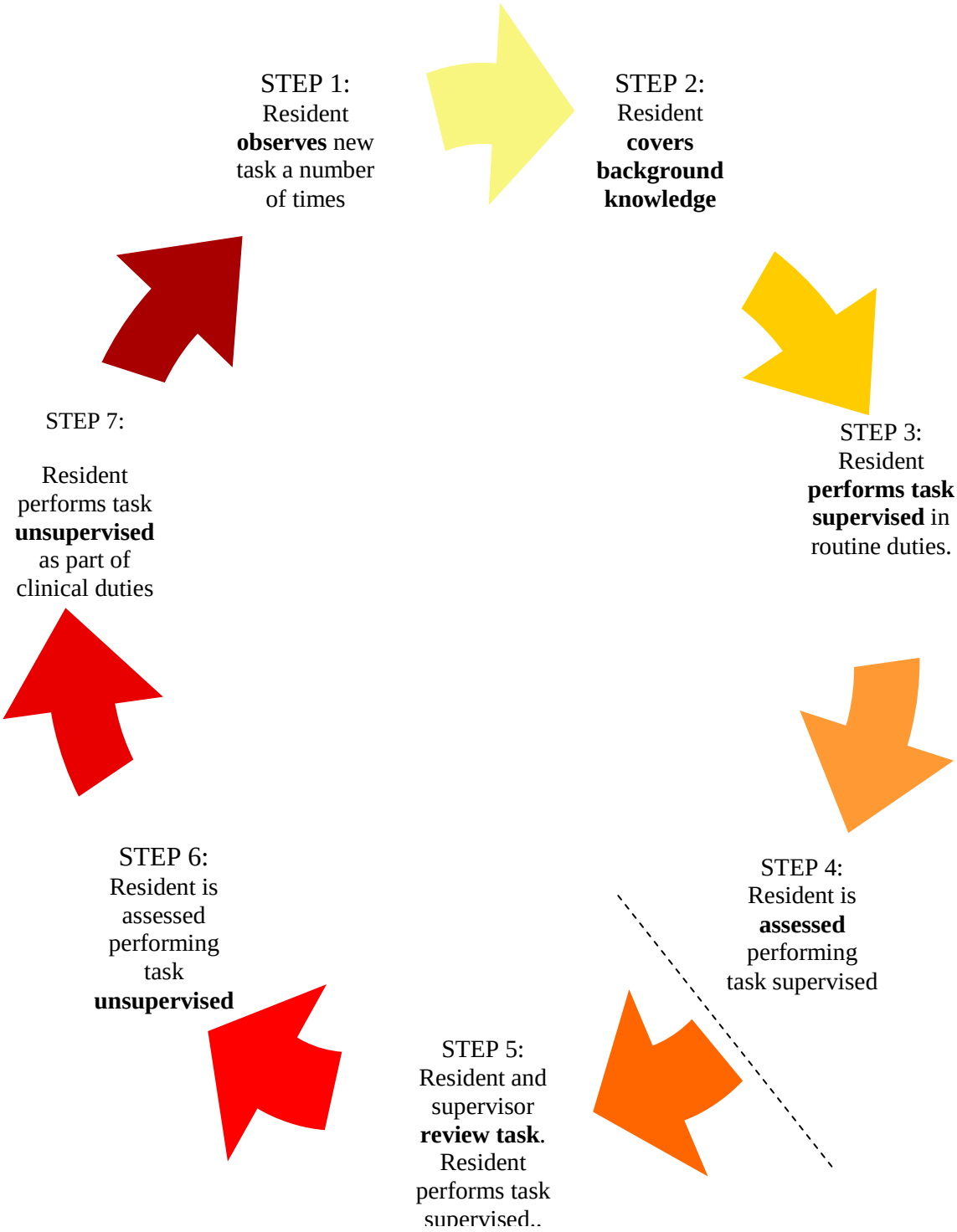

FIG. I.2: Timeline of clinical training and competency assessment. Step 4 to Step 5 may occur after the Resident has had some experience.

I.5. IMPORTANT APPENDICES

In addition to the current appendix there are several other appendices which are of importance to you as a Resident in the programme. These are:

- *The Clinical Training Guide Appendix IV*
- *Competency Assessment Appendix V*
- *The Supplementary Forms and Documents Appendix VI.*

You should keep a hard copy of each of these appendices. You will need to refer to the Clinical Training Guide frequently during you residency and the Competency Assessment appendix will need to be updated as competencies are tested by your Clinical Supervisor or nominee. It may also be inspected by the National Programme Coordinator, the external coordinator or external advisor.

I.6. RESIDENT RECRUITMENT

Residents can only be recruited by departments which have been approved by the National Steering Committee for clinical training of Residents in this programme. The prospective Resident must submit a completed "Application for Entry" form to the National Programme Coordinator (see Appendix VI) and only becomes a Resident when this application has been approved by the National Programme Coordinator and the external coordinator in the case of the IAEA pilot programme.

As a prospective Resident you should have a clear understanding of the expectations and duration of the clinical training programme. Also see Appendix III.4 (Entry requirements for residents).

I.7. NEW RESIDENT ORIENTATION

In addition to the regular hospital and departmental orientation, a new Resident will be given an orientation to the Clinical Training programme in their country.

The first meeting between yourself as a new Resident and your Clinical Supervisor will cover many aspects including the following:

- Explanation of the Clinical Supervisor's role.
- Expectations for the Clinical Training Programme.
- Responsibilities of the Resident in the Clinical Training Programme.
- The evaluation and assessment schedule (including a regular time for at least monthly meetings).
- Notification of the timing of external assessment including annual reviews.
- Direction to resources (e.g. sample assignments, access to basic text books, etc.).
- Availability of scholarships and other funding to attend courses and conferences.
- Requirement to attend seminars, clinical meetings and level of participation expected.
- Role of National Programme Coordinator and other relevant persons outside the department.
- General employee duties and responsibilities.
- Questions from the Resident.

In this meeting you should also discuss with your Clinical Supervisor the following training materials:

- Draft learning agreement including training schedule for the first six months.
- Resources for appropriate documentation requirements

In order to support the clinical training programme as defined by the clinical competencies, it will be necessary to obtain a selection of the knowledge sources found in the guide. There has been an effort to use high quality resources that are downloadable, such as the reported available from the American Association of Medical Physics (AAPM). In addition to this the resident should be aware of the HINARI Access to Research Initiative, http://www.who.int/hinari/en/, which allows residents from some locations to have access to downloadable research articles that are otherwise available only for a fee. In addition the resident is strongly encouraged to purchase a sufficient set of texts that cover most areas of clinical experience for the list of knowledge sources in the modules.

I.8. RESIDENT AGREEMENT WITH SUPERVISOR

Within the first two months a new Resident and his/her Clinical Supervisor should finalise a learning agreement, including learning needs, schedule of training, objectives, resources and strategies. Learning agreements should include a schedule for achievement of specific competencies in the next 6 months as well as an overview of the schedule for completion of the entire training programme (see section 10 for an explanation of competency as used in this programme).

You need to be aware that the schedule may need to be changed.

Requirements including the scope of competencies and the assessment criteria should be discussed.

The advantages of a learning agreement include:

- Identifying learning needs and resources,
- Providing a forum for discussion of the feasibility of goals relative to the timing and size of workload for the department, Supervisor and Resident,
- Encouraging communication between the Resident and Supervisor,
- Giving you, the Resident, a sense of ownership and commitment to the plan and it is clearly conveyed that you need to take responsibility for your own learning,
- Creating and implementing a strategy which is important due to the volume and scope of work to be completed in the training programme, and
- Prompting evaluation.

Disadvantages include the need for regular updating of the plan as timing of a significant portion of clinical training may be difficult to predict.

As soon as practical, a plan for successful completion of the clinical training programme on schedule should be developed, identifying:

- Short, medium and long term learning outcomes;
- Timing of final (national) assessments to permit prioritization of competency completion;
- Timing of research and clinical requirements, including courses and conferences;
- Timing of clinical rotations, such as Radiation Oncology and other Diagnostic Radiology Centres;
- Possible areas for at least 5 key portfolio reports of the Resident's best work to be developed over time (see Section 9);
- Level of independence required;
- A contingency plan for spare time e.g. assignments or knowledge-based competencies;
- Potential issues or situations that may impact on the training experience, such as major changes within the department;
- Opportunities for practice-based learning. For example, attending machine break-downs to observe trouble shooting.

A sample template to assist with the preparation of a learning agreement is provided in the appendix "Supplementary Forms and Documents".

However, the Supervisor and Resident may choose a document that suits their style and is not too time intensive (relative to their needs). An alternate method can be chosen as long as it conveys all the required information and prompts the allocation of resources and staff to support the clinical training.

The learning agreement must be mutually agreed upon as it has to be feasible for both parties and acknowledge the responsibility of both Resident and Supervisor to meeting deadlines. It should take into account departmental and supervisor requirements. Advantages of a learning agreement include:

- Ensuring that the assessment of a significant number of competencies are not left to very late in your programme;
- Planning items of training which require access to equipment or cooperation of other staff.

You will need to have or develop good time management skills in order to fulfil your responsibilities of the learning agreement.

The forms **ANNUAL CHECKLIST FOR RESIDENTS** and **COMPLETION CHECKLIST FOR RESIDENTS** which are two further checklists (Appendix VI) to prompt discussion and completion of requirements.

Note that a Supervisor cannot be held responsible for not completing competency assessment before a deadline if you do not meet milestones or submit a significant amount of work for assessment at the last minute.

It is expected that you may initially need careful guidance to ensure that you achieve milestones and levels of competency as per your learning agreement. However as you progress through the programme, you must become more active and self-directed and accept a

greater level of responsibility. It is part of the role of a Clinical Supervisor to guide the Resident through this professional development. One approach to clinical training and competency assessment is shown schematically in Fig. I.2.

I.9. ASSESSMENT

There are several components to the assessment of a Resident in the Clinical Training Programme

- **Competencies** (as per the sub-modules of the Clinical Training Guide)

  Each sub-module defines a unified portion of clinical knowledge or skills. All competencies (or sub-modules) required are listed in the Clinical Training Guide. The sub-modules to be undertaken and the level of competency achieved required in each sub-module have been determined by the Responsible National Authority, or its delegate, and are indicated in the Clinical Training Guide (see Appendix III.3.1.1).

  The Clinical Supervisor can schedule competency assessment at any agreed time. The sub-modules can be undertaken in any order and more than one module can be undertaken at a time. The assessment should comply with the learning agreement and focus on one or a number of the following factors:

  - **Clinical work**, i.e. qualified staff formally observe routine clinical tasks as on-going assessment of competence,
  - **Module-focussed**, i.e. clinical work is assigned and responsibility given, once the competencies within a particular module are covered, e.g. commissioning of equipment can be assigned once the resident has shown ability in routine quality control testing.
  - **Commissioning-focussed**, i.e. scheduling of competencies is related to departmental commissioning projects. This is opportunistic learning and may incorporate several areas of competencies.

  It is expected that many competencies will be assessed on several occasions. For example: a particular competency might be worked on for some time and the Resident assessed as having obtained a level of 3. The Resident might then be rostered to another area and return to work on the first competency (sub-module) at a later time with a second assessment being conducted at the end of this period. Following any assessment of competency the Resident will be provided with supportive and corrective feedback. You should not be upset by this feedback. Note that the assessor is indicating to you how you can improve your performance in the programme.

  The competency assessment criteria are provided in the Clinical Training Guide. As demonstrated by the criteria, competency assessment is not just reviewing technical ability but also attitudes, such as safe practice and communication skills, expected of a qualified medical physicist specialising in nuclear medicine.

- **Portfolio**
  The portfolio provides you with an opportunity to demonstrate the breadth and depth of your knowledge on certain topics. It is also useful for external competency assessment, evidence of level sign-off, development of scientific writing skills and can be used as proof of competence if appealing an exam result. Each resident should have a folder of evidence that the portfolio reports can be taken from for submission.

The Clinical Supervisor will examine the folder of evidence at regular (at least 6 monthly) intervals and provide feedback to the Resident. The National Coordinator or their delegate will review the folder of evidence at the end of each year of the Resident's programme and rate the evidence as satisfactory or unsatisfactory.

The submitted portfolio incorporates the follow documents:

- Curriculum vitae
- Progress reports
- "Summary of Competency Achievement" demonstrating the level of competency achieved in each sub-module.
- Samples of work prepared by the Resident from at least 3 of the 5 core modules of the Clinical Training Guide. The samples of work could be:
    - Departmental reports, e.g. commissioning and clinical implementation of new equipment or treatment technique.
    - Assignments on key competencies.
    - A research paper published in a local or peer-reviewed journal
    - A research presentation in a national or international meeting
    - A presentation delivered covering key aspects of the module

Each portfolio report should ideally be less than 10 pages (10 font, single line spacing, and single-sided pages). Lengthy reports are discouraged, therefore tables and graphs of data may be referred to but not included.

- **Assignments**
  Three assignments must be submitted during the training programme. These should be submitted no later than approximately 9, 15 & 21 months after commencement of the training programme. (This schedule for submission may be altered by the National Steering Committee) These assignments will be marked by an appointee of the National Steering Committee and possibly by an external reviewer nominated by the external coordinator and be returned, within one month of submission, to the Resident so as to provide feedback. You should discuss the feedback received with your Clinical Supervisor.

  The assignments will be graded on a 5 to 1 scale with grades of 4 and 5 being unsatisfactory, 3 just satisfactory, 2 good and 1 excellent.

  When a grade of 4 or 5 is awarded you will be required to modify the assignment, taking into consideration the feedback provided, and to resubmit the assignment within 1 month for further assessment.

- **Written Exam**
  The written exam is optional, at the discretion of the National Steering Committee or delegate. The content of the written exam is based on the core modules of the Clinical Training Guide but may cover any application of relevant knowledge in the field of Nuclear Medical Physics. The written exam tests a deeper understanding than assessed in the MSc.

- **Oral Exam**
  This is administered by the National Steering Committee at the end of the training programme. Before taking the oral exam a Resident must satisfactorily complete ALL

other aspects of assessment. The content of the oral exam will include a significant component from the portfolio and the remainder will be drawn from elsewhere in the Clinical Training Guide.

- **Practical Exam**
  The practical exam is optional (i.e. at the discretion of the National Steering Committee) and, is ideally, linked to a professional accreditation process. The practical examination is based on scenarios that a medical physicist may encounter at a senior level and incorporates a range of competencies covering the Clinical Training Programme.

- **A Logbook**
  A logbook is recommended but is not obligatory and is not included in the assessment process. If used, the logbook should be maintained by the Resident and contain a record of training experiences with comments as to difficulties experienced and positive learning outcomes. The logbook can also be utilised by the Supervisor to demonstrate that sufficient work has been covered to sign off a competency if it is difficult for the Supervisor to perform practical assessment of that competency. The logbook can be in hard copy or electronic form.

NOTES:

- The Resident must be assessed as satisfactory in each of the above components to be successful in the total programme.
- The required level of competency in ALL sub-modules must be achieved before the oral exam can be attempted.
- The oral examination, and practical examination if required, are designed to assess whether the candidate has the appropriate approach of a qualified medical physicist i.e. to work unsupervised in a professional, scientific and safe manner. However as limited technical knowledge and competency can be assessed in these examinations, for the assessment of the majority of the medical physicist's roles and responsibilities it is the assessment of competency in actual practice which has a pivotal role in ensuring safe, competent practice.

I.10. EXAMPLES OF COMPETENCY ASSESSMENT TOOLS WHICH YOU MIGHT EXPERIENCE

There are many possible methods by which your competency in a particular sub-module may be assessed. The assessor may

- observe, listen and question you during routine clinical experience
- listen to you teaching someone else
- provide you with mock scenarios. Examples:
  - communication with patient or colleague (perhaps also a patient based dilemma)
  - request that you write a commissioning schedule for a SPECT/CT scanner
  - commissioning an PET/CT scanner
  - commissioning a dose calibrator
- suggest that you attend
  - an internal course on conflict management
  - attend a university course for postgraduate students on oral presentation.

- ask a patient or another professional's feedback of how you communicated with them.
- use oral assessment in a regular Supervisor-Resident meeting Short written report with assessment and constructive feedback
- use practical assessment including oral questioning whilst you perform a routine task (e.g. quality assurance, dose calibration)
- use objective, structured clinical examinations or series of defined clinical tasks.
- review your logbook.
- set clinical project work
- set patient or equipment trouble-shooting case studies
- ask that you list key steps involved in completing a task
- require an external competency test at another department
- review your portfolio.
- request that you participate in a local tutorial programme
- use self-reflection. Do not be surprised if your supervisor asks "how do you think you went?" after completing a competency assessment.
- suggest that you make a presentation to departmental staff
- require that you write
    - sample letters that are assessed by the supervisor on key points.
    - a report on the role of other professional groups.
    - a report on the pathway of a patient from diagnosis to treatment.
- suggest that you compile decision-making diagrams.
- suggest that you critically appraise a journal article in a departmental "Journal Review Meeting".

I.11. CLINICAL ROTATIONS

The Resident may be required to obtain training in other hospitals for periods of time to gain experience in techniques or on equipment not available in the Resident's own hospital. The clinical training guide also requires the Resident to gain knowledge and competencies in Radiology and Radiation Oncology.

APPENDIX II
HANDBOOK FOR CLINICAL SUPERVISORS

ACKNOWLEDGEMENTS

This appendix has been based on the Handbook for Residents developed in New South Wales (NSW) for use in the Training, Education and Accreditation Programme (TEAP) of the ACPSEM for registrars in radiation oncology medical physics. The input of NSW Health is gratefully acknowledged.

II.1. INTRODUCTION

A necessary component of the training of Residents is the guidance provided by a Clinical Supervisor. This handbook is designed to assist Clinical Supervisors in understanding the roles and responsibilities of the position.

The investment of time and effort in training Residents is repaid as they become more experienced and increase their contribution back to the department. Adequate clinical training resources are essential for the successful implementation of the programme. One of the major resources required within a participating department is the Clinical Supervisor. This appendix outlines the roles and responsibilities of the Clinical Supervisor.

It is important that this appendix is carefully read before commencing Clinical Supervision of a Resident. The Clinical Supervisor should also be familiar with the C*linical Training Guide*

(Appendix IV) and all associated documentation. A list of useful resources (URLs etc.) for Clinical Supervisors is provided in section II.16.

II.2. APPOINTMENT OF A CLINICAL SUPERVISOR

A suitably qualified and experienced Clinical Supervisor should be appointed by a department seeking to participate in the pilot of the RCA clinical training programme. It is important that the Clinical Supervisor has the confidence and willingness to undertake the roles and responsibilities of the position.

The steps in the appointment of a Clinical Supervisor are

- The Chief Physicist, normally, initiates the nomination and makes the proposed Clinical Supervisor aware of the expectations of the position and the impact the supervisory role may have on his/her other duties.
- The proposed Clinical Supervisor should agree to the nomination which needs to be approved by the Head of the Department and the National Programme Coordinator.
- An agreement between the Clinical Supervisor and Chief Physicist is made to ensure effective supervision takes place. If possible, an adjustment of the supervisor's other workload is made to account for the time necessary for administration, training, and assessment of the Resident(s).

The logistics and resources of how training fits into the function of the department also need to be considered. For example the Clinical Supervisor and Chief Physicist should discuss:

- allocation of time on equipment during normal working hours for training and/or assessment (if possible);
- allocation of overtime funding or flexibility for the Supervisor and other staff involved in the clinical training to take "time-off in-lieu" for training conducted outside normal working hours which may be necessary so that the Resident can gain additional access to equipment;
- allowance for clinical supervision workload when distributing roles and responsibilities in the department;
- acknowledgement of the importance of the clinical supervision role to the Resident and department.

II.3. ROLES AND RESPONSIBILITIES OF CLINICAL SUPERVISORS

The clinical supervisor's responsibilities include:

- Ensuring that the Resident is trained in all significant aspects of nuclear medicine physics by facilitating a structured training programme in keeping with the guide and with the scope of modules and assessment levels to be completed as determined by the National Steering Committee. Note that this does not mean that all the training is done by the supervisor. It is the responsibility of the supervisor to ensure that suitably qualified specialists undertake the training of the Resident in the various facets of the programme. For further guidance on this please see below in Section 10 "Models of Supervisory Practice".

- Meeting regularly with the Resident to discuss progress (including reviewing deadlines) and adequate supportive and corrective feedback to the Resident such as the level of competency achieved and competency achievements which have fallen behind. (Note: in this document a "meeting' indicates a face-to-face meeting, videoconference or other means as the circumstances allow/require.)
- Providing a six monthly report on the Resident's progress to the National Programme Coordinator.
- Ensuring that the Resident's clinical training and performance is monitored, documented, assessed and reported as required.
- Ensuring that the in-service clinical training is provided to a standard acceptable to the National Steering Committee and providing to the Resident support where required.
- Ensuring that the Resident is placed in other hospitals, where possible, for short periods to gain experience in techniques or the use of equipment not available in the Resident's own department.
- Ensuring that the Resident has sufficient opportunity to prepare for all assessments required as part of the programme.
- Facilitating external assessments of Residents during their training where possible.

Clinical supervisors should be life-long learners themselves. It is also recommended that every Clinical Supervisor attends a "train the trainer" workshop (if possible) to understand the educational framework of the Clinical Training Guide prior to commencement of training.

II.4. NATURE OF A SUPERVISOR

Clinical education (best) occurs in an environment supportive of the development of clinical reasoning, professional socialisation and lifelong learning, (McAllister 1997). Supervisors should reflect on what helped them learn during their own training and use their own experiences as one guide to providing the best practice in clinical training.

The attributes required of a good supervisor are varied and are listed below:

- **As a manager**
  The supervisor needs to be organised and to provide clear guidance of expectations, clinical work roster, deadlines and assessment criteria to the Resident. In addition the supervisor needs to liaise with other department and external personnel to ensure that the clinical training and day-to-day supervision are not impeded

- **As an instructor**
  Components of instruction for a Clinical Supervisor include:
  - the Supervisor demonstrates to the learner
  - the Resident practises while the Supervisor offers feedback
  - the Supervisor provides support that is gradually reduced as the Resident becomes more proficient
  - the Resident describes his or her problem-solving processes
  - the Resident reflects on the comparison between individual problem-solving processes with those of a peer or more experienced physicist
  - the Resident moves to independent problem-solving

Other facets of instruction include:

- providing suitable conditions for self-directed learning
- directing the Resident's attention towards significant factors of a task (and order of a group of related tasks).
- imparting the hidden secrets of mastery, rather than just the mechanics of a task
- ensuring basic knowledge and skills are mastered before more complex tasks are undertaken.

- **As an observer**
  The Clinical Supervisor should take every opportunity to observe the Resident undertaking tasks. This is not only important in the provision of timely supportive and corrective feedback but should be a key element of the assessment process.

- **As a mentor**
  This role may be undertaken by a person other than the Clinical Supervisor. It is important that the "mentor" is someone that the Resident chooses to perform this role.

  Residents are often young adults experiencing considerable social and financial pressures. A mentor may be requested to discuss a Resident's personal issues and should take time to understand the background of the Resident without invading their privacy. If a Clinical Supervisor is willing to act in this role and the Resident agrees, then the Supervisor must only counsel within their own limitations and skill level. If the Resident requires assistance outside a mentor/Clinical Supervisor's skill level, comfort zone or ethical/confidentiality/privacy/assessment role boundaries then they should refer the Resident to the Chief Physicist or Hospital/University Counselling Service. Furthermore, the Clinical Supervisor should encourage or at least make the Resident feel comfortable to seek external help if required.

- **As a giver of feedback**
  Feedback to Residents should consist of supportive as well as corrective feedback. It should also be varied, non-judgemental, specific, focussed on changeable behaviour, descriptive, prompt and private (if professionally appropriate or if the Resident is sensitive to corrective feedback). The Clinical Supervisor should note that questioning often facilitates discussion of corrective feedback (e.g. "how do you think you went?").

- **As an assessor**
  The role of assessor of clinical competency is one of the most important and difficult responsibilities of the Clinical Supervisor. "Transparency" of the assessment is essential and requires that the Resident:

  - is provided with a clear statement of expectations (knowledge and skill level required) to be successful (The *Clinical Training Guide* includes some detail related to assessment of the level of competency achieved)
  - understands the reasons for the level assessed (what was done well, deficiencies in knowledge or skills). It is good practice to explain why the level was chosen and not a level either side, for example if assessing a competency at level 3 then explain why level 2 or 4 was considered to be inappropriate.
  - is provided with supportive feedback following the assessment of any aspect of clinical training (competency, assignment etc.).

The "validity" of the assessment is also important. The logbook, if used, can perform a vital role in assessment by demonstrating the tasks that contributed to completion of competencies.

The role of the instructor and/or assessor can be delegated by a Clinical Supervisor to other suitably qualified medical physicists (or other professionals in the case of imaging and radiobiology) if the Resident is working in an area of their clinical responsibility. For example, a resident may work under and be assessed by a medical physicist responsible for PET/CT. For further guidance on this please read Section 10 "Models of Supervisory Practice".

II.5. RESIDENT RECRUITMENT

Before recruiting a Resident you should ensure that

- Your department is approved by the National Steering Committee for clinical training of Residents in this programme.
- The prospective Resident has submitted a completed "Application for Entry" form and that this application has been approved by the National Programme Coordinator and the external coordinator in the case of involvement in a pilot programme.
- You have read the Clinical Training Guide and are aware of the scope of modules and assessment levels adopted in your country
- The prospective Resident has a clear understanding of the expectations and duration of the clinical training programme

Also see Appendix III.4 (Entry requirements for residents).

II.6. NEW RESIDENT ORIENTATION

In addition to the regular hospital and departmental orientation, a new Resident should be given an orientation to the Clinical Training programme in their Country. Before this orientation they should read the Clinical Training Guide.

The first meeting between the Clinical Supervisor and new Resident should cover many aspects including the following:

- Explanation of the Clinical Supervisor's role;
- Expectations for the Clinical Training Programme;
- Responsibilities of the Resident in the Clinical Training Programme;
- The evaluation and assessment schedule (including a regular time for at least monthly meetings);
- Notification of the timing of external assessment including annual reviews;
- Direction to resources (e.g.. sample assignments, access to basic text books, etc.);
- Availability of scholarships and other funding to attend courses and conference;
- Requirement to attend seminars, clinical meetings and level of participation expected;
- Role of National Programme Coordinator and other relevant persons outside the department;

- General employee duties and responsibilities;
- Questions from the Resident;

In this meeting you should discuss and provide your Resident with the following training materials:

- Draft learning agreement including training schedule for the first six months.
- Resources for appropriate documentation requirements

A checklist is provided in Form 1 CHECKLIST FOR NEW RESIDENTS to ensure all key aspects are covered (Appendix VI).

II.7. RESIDENT AGREEMENT WITH SUPERVISOR

II.7.1. Learning agreement and plan

Within the first two months a new Resident and his/her Clinical Supervisor should finalise the learning agreement, including learning needs, schedule of training, objectives, resources and strategies. Learning agreements should include a schedule for achievement of specific competencies in the next 6 months as well as an overview of the schedule for completion of the entire training programme. The Resident should be made aware that the schedule may need to be changed.

Requirements including the scope of competencies and the assessment criteria should be discussed.

The advantages of a learning agreement include:

- Identifying learning needs and resources;
- Providing a forum for discussion of the feasibility of goals relative to the timing and size of workload for the department, Supervisor and Resident;
- Encouraging communication between the Resident and Supervisor;
- Giving the Resident a sense of ownership and commitment to the plan and it is clearly conveyed that they need to take responsibility for their own learning;
- Creating and implementing a strategy which is important due to the volume and scope of work to be completed in the training programme; and
- Prompting evaluation.

Disadvantages include the need for regular updating of the plan as timing of a significant portion of clinical training may be difficult to predict.

As soon as practical, a plan for successful completion of the clinical training programme on schedule should be developed, identifying;

- Short, medium and long term learning outcomes;
- Timing of final (national) assessments to permit prioritization of competency completion;
- Timing of research and clinical requirements, including courses and conferences;

- Timing of clinical rotations, such as Radiation Oncology and other Diagnostic Radiology Centres;
- Possible areas for at least 5 key portfolio reports of the Resident's best work to be developed over time;
- Level of independence required;
- A contingency plan for spare time e.g. assignments or knowledge-based competencies;
- Potential issues or situations that may impact on the training experience, such as major changes within the department;
- Opportunities for practice-based learning. For example, attending machine break-downs to observe trouble shooting.

However, the Supervisor and Resident should choose a document that suits their style and is not too time intensive (relative to their needs). An alternate method can be chosen as long as it conveys all the required information and prompts the allocation of resources and staff to support the clinical training.

The learning agreement must be mutually agreed upon as it has to be feasible for both parties and acknowledge the responsibility of both Resident and Supervisor to meeting deadlines. It should take into account departmental and supervisor requirements.

After being accustomed to an academic environment, many Residents struggle with time management when they commence their clinical training programme. A Clinical Supervisor should assist the Resident in developing time management skills.

The forms ANNUAL CHECKLIST FOR RESIDENTS and COMPLETION CHECKLIST FOR RESIDENTS are two further checklists to prompt discussion and completion of requirements (See Appendix VI).

II.7.2. Compliance

At regular and six monthly progress review meetings, the learning agreement should be examined. If there is an identified lack of progress by the Resident, the reasons behind the delay need to be determined. Hence the learning needs, objectives, resources and strategies should be re-examined, including:

- An examination of the clinical learning environment to ensure that the environment is conducive to learning. In some cases delays may be due to a lack of initiative, unwillingness to accept responsibility, inability to manage the competing demands in the workplace, Resident immaturity resulting in unsafe practice.
- Development of a mutually agreed action plan to provide the Resident with specific guidance and support to facilitate progress. The action plan must be documented and should detail the following:
    - Agreement as to the exact area/s where problem/s are identified;
    - Specific details of how the problem area/s will be addressed;
    - An agreed period of time for further supervised practice;
    - An agreed minimum contact time per week that the Supervisor and Resident will practice together.

A record of the meeting should be made.

A Supervisor cannot be held responsible for not completing competency assessment before a deadline if the Resident did not meet milestones or submitted a significant amount of work for assessment at the last minute. It is recommended that a Resident and Clinical Supervisor should not schedule a significant amount of competency assessment within the final months of the training programme so as to minimise the possibility that unexpected events such as an increase in department workload, leave, staff shortages, etc. might prevent completion of competencies and assessment prior to final exams.

II.8. MODELS OF SUPERVISORY PRACTICE

When first enrolling, the Residents may be passive and used to being "spoon-fed" at university. They may need guidance on appropriate conduct at work and style of communication with multidisciplinary professionals (internal and external) and with patients. As they progress through the programme, the Residents must become more active and self-directed and accept a greater level of responsibility. It is part of the role of a Clinical Supervisor, with the assistance support through mentorship, to guide the Resident through this professional development. One approach to clinical training and competency assessment is shown schematically in Fig. II.2.

As in the past, a Resident trains "on-the-job" under the direction of experienced staff. However the difference with the previous "ad hoc" approach is that the Resident's clinical training is structured, follows a set of knowledge and competencies and is monitored internally and externally more closely.

There are two main models of Supervision. However one supervisor model is not always appropriate throughout the programme and for all Residents. The two models of supervision are:

(1) "Qualified medical physicists specialising in nuclear medicine per Resident" approach – the majority of training and assessment is performed by the one medical physicist. This is difficult when the Clinical Supervisor is very senior in the department and/or works restricted hours. This approach is more common in small centres.

(2) "Qualified medical physicists specialising in nuclear medicine per module" approach - the Supervisor acting as a local coordinator delegates training and assessment of specific competencies to alternative experienced medical physicist. This approach is more common in larger centres. The local coordinator allocates competencies and reviews progress and assessment, compiles six monthly supervisor reports (in consultation with the other medical physicists involved in training) and communicates with the National Programme Coordinator. In some cases the local coordinator does all the competency assessment which increases the validity of assessment as it is independent of the medical physicist who performed the training. The latter role is difficult when the Clinical Supervisor is a Chief Physicist or works restricted hours. Note: The Clinical Supervisor is not required to do all the training and assessment. However, they are responsible for ensuring appropriate training and assessment is carried out according to the national guidelines.

II.9. ASSESSMENT

See assessment in Appendix I.10.

NOTES:

- The Clinical Supervisor must have an objective and impartial approach and not be biased when assessing a Resident.
- The Resident must be assessed as satisfactory in each of the above components to be successful in the total programme.
- The required level of competency in ALL sub-modules must be achieved before the oral exam can be attempted.
- The oral examination, and practical examination if required, are designed to assess whether the candidate has the appropriate approach of a qualified NMP i.e. to work unsupervised in a professional, scientific and safe manner. However as limited technical knowledge and competency can be assessed in these examinations, for the assessment of the majority of the NMP's roles and responsibilities it is the assessment of competency in actual practice which has a pivotal role in ensuring safe, competent practice.
- Where ever possible supervisor should provide assessment criteria and/or sample exam questions before an assessment

II.10. EXAMPLES OF COMPETENCY ASSESSMENT TOOLS

- Observe, listen, question during routine clinical experience;
- Listen to Resident teaching someone else;
- Mock scenarios:
  - communication with patient or colleague (perhaps also a patient based dilemma, e.g. patient who doesn't speak the local language);
  - write a commissioning schedule for a new PET/CT scanner;
  - commissioning an SPECT scanner;
  - commissioning a dose calibrator.
- Attend an internal course on conflict management;
- Attend a university course for postgraduate students on oral presentation;
- Ask a patient or another professional's feedback of how the Resident communicated with them;
- Oral assessment in a regular Supervisor-Resident meeting (however performance anxiety may reduce the validity of assessment particularly early in the programme);
- Short written report with assessment and constructive feedback;
- Practical assessment which includes oral questioning whilst a Resident performs a routine task (e.g.. quality assurance, absolute calibration);
- Objective, structured clinical examinations or series of defined clinical tasks;
- Logbook review demonstrates degree of exposure to certain tasks;
- Clinical project work;
- Patient or equipment trouble-shooting case studies;
- Resident lists key steps involved in completing a task;
- External competency test at another department;
- Portfolio reports provide the opportunity for a Resident to show-off the breadth and depth of their knowledge on certain topics;
- Problem based learning programme;
- Local tutorial programme;
- Self-reflection. The supervisor can ask "how do you think you went?" and provide feedback. A supervisor may also provide criteria for a task to allow the Resident to self-assess;

- Presentation to departmental staff;
- Write sample letters that are assessed by the supervisor on key points;
- Report on the role of other professional groups;
- Report on the pathway of a patient from diagnosis to treatment;
- Compile decision-making diagrams;
- Critical appraisal of journal articles in Journal Review Meetings.

NOTE: Competency assessment demonstrates normal achievement of goals and doesn't always encourage Residents to extend themselves to achieve their full potential. In contrast, the Portfolio gives the Resident the opportunity to demonstrate excellence.

II.11. RESIDENT MOTIVATION

Success of the clinical training programme relies on the Resident undertaking self-directed study including determining and meeting deadlines (i.e. individual accountability). Difficulty completing the programme is expected to be encountered when the Resident has low initiative and/or is slow to accept responsibility. In contrast, pathways for advancing talented and/or experienced Residents before their recommended completion date need to be considered.

It is recommended that Supervisors document all lapsed deadlines and unacceptable behaviour. Serious concerns must be discussed with the Resident. If necessary, co-opt another party e.g. a mentor, Chief Physicist or National Programme Coordinator to participate in these discussions.

If a Supervisor has met the requirements of their position but the Resident continues not to achieve the required standard and/or goals, this may be due to a number of reasons. Strategies for addressing some of these issues are indicated in the table below.

TABLE II.1. RESIDENT MOTIVATION STRATEGIES

	ISSUE	STRATEGY IDEAS
A	A new Resident has difficulty knowing where to start, what to do and how to put it together and therefore may struggle if thrown "in the deep end".	-Start with basics and increase the complexity as the Resident's level of understanding improves (if feasible). -Supervisor organises more one-on-one time to explain their thought processes for troubleshooting.
B	Learning activities are different to the learning style of the Resident.	-Tailor learning activities to the learning style and maturity of the resident if possible (e.g. visual learners). -Explain expectations of self-directed learning to those Residents used to didactic learning. -Set shorter, more regular, deadlines for achievement of milestones.
C	Assumed prior knowledge or experience doesn't exist.	-Start with more basic activities (if feasible).
D	Personal issues (relationship issues, mental or physical health problems, financial difficulties, remote from family, etc.),	-While in some cases a mentor can assist, these issues are often best referred to the hospital/university counsellor or chief physicist. -Review and re-design the learning agreement to give the Resident time to adjust to a new environment.
E	Difficulties communicating expectations between supervisor and Resident	-Write down each other's perspectives and try to understand the other point of view. -Ask the Resident to repeat instructions to determine if they have interpreted your instructions correctly. -Resident to work under another medical physicist (internal or external) for a period of time.

	ISSUE	STRATEGY IDEAS
F	Resident has difficulties communicating effectively with others in the Nuclear Medicine Department.	-Mock scenarios to practice appropriate communication styles (for staff and patients). -Encourage participation in social activities which minimise isolation. -Resident to attend "Communication skills" courses including "Communicating with others" or "Conflict resolution" course if relevant.
G	Resident shows lack of initiative.	-Balance the positive and critical feedback carefully. -Review and re-design the learning agreement to include shorter and more regular deadlines to achieve milestones. -Identify activities related to Resident's value system to draw out enthusiasm. -Increase clinical interaction time to draw them away from their desk. -Open/honest discussion of expectations. -Allocate an area of responsibility to the Resident if they feel indifferent as they don't have their own niche. (if appropriate) -Peer-support system with another Resident. -Formative assessment if feasible. Anxiety can be created from a lack of regular assessment or feedback.
H	Not willing to work out of hours	-Discuss conditions of employment and relevant issues (e.g.. personal) if progress is behind schedule.
I	Difficulties managing competing priorities	-Regular meetings with Resident to review the Resident's work/ priorities. -Time management course.
J	Difficulties with scientific thinking and is more suited to a technically-based profession	-Explain expectations. -Start with basic scenarios and increase the complexity as their level of understanding improves (if feasible). -Supervisor organises more one-on-one time to explain their thought processes for troubleshooting. -If unresolved, refer them to their mentor to review career options. -Stop the placement.
K	Difficulties identifying opportunistic learning avenues.	-Supervisor, initially, identifies avenues for opportunistic learning as often such opportunities are one-off and not planned. This should be for a limited period only. -Allow them to work with someone (engineer, medical physicist) for a period of time. -Increase clinical interaction time. -If appropriate, make them responsible for an item of equipment for a period of time.

II.11.1. If a Resident fails to meet required standards

Termination of the clinical training position should be considered if the Resident fails to meet the standards required in the programme following a period of supportive and corrective feedback and opportunity to improve. If this does occur, do not feel as though you have failed the Resident. . Rose and Best (2005) note "you don't fail the Resident….the Resident fails the assessment. In a well-developed assessment system with clear expectations and criteria, adequate feedback for the student and opportunities for improvement, the student should have had every opportunity to achieve the desired standard".

The department is responsible for the continuation of the employment of the Resident. Where progress of a Resident is unsatisfactory then the National Programme Coordinator should communicate with the employing department.

II.12. CLINICAL ROTATIONS

The Resident may require training in other training hospitals for periods of time to gain experience in techniques or on equipment not available in the Resident's own hospital.

Aspects to consider when rotating Residents to other departments include:

- Time constraints imposed by completion of the clinical training programme, and distances to be travelled by the Resident;
- The pre-requisite knowledge should be completed before any Clinical Rotation is undertaken;
- The visiting Resident should work on competencies related to the rotation's focus area but must also be flexible enough to work within the busy schedule of the Host department;
- A Resident can visit another department for varying amounts of time, from a day up to months at a time;
- A clinical rotation can also include a competency test conducted by an experienced person in the Host department;
- The responsibility of coordinating the clinical rotation and delegation of competency assessment during this placement remains with the Clinical Supervisor.

Expectations of both departments and competencies to be addressed, should be documented prior to the commencement of the clinical rotation

II.13. Bibliography

MCALLISTER, L., (Ed.) Facilitating learning in clinical settings, Stanley Thornes, Cheltenham, UK, (1997).

ROSE, M., BEST, D., (Eds), Transforming practice through clinical education, professional supervision and mentoring, Elsevier, (2005).

II.14. USEFUL RESOURCES FOR CLINICAL SUPERVISORS

EFOMP

- http://www.efomp.org/docs/CurriculumForMP.pdf
- http://www.medfys.no/misc/EFOMP-Policy1upd_draft4.doc

Mentoring

- http://www.edu.uwo.ca/conted/mentor/index.asp
- "ACPSEM Guide for Mentors". (2004) Mellish and Associates.
- http://www.uscg.mil/leadership/mentoring/mentguid.ppt#1
- http://www.usfirst.org/uploadedFiles/Community/FRC/Team_Resources/Mentoring%20Guide.pdf
- http://www.mentorlinklounge.com/

Clinical Supervision

- "Teaching on the run" is something that physicians, RTs and physicists all have in common when providing clinical training (see Table II.2). http://www.mja.com.au/public/issues/contents.html

Table II.2 Teaching References

Teaching on the run tips: doctors as teachers Teaching on the run tips 2: educational guides for teaching in a clinical setting	MJA 2004; 181 (4): 230-232 MJA 2004; 180: 527-528
Teaching on the run tips 3: planning a teaching episode	MJA 2004; 180: 643-644
Teaching on the run tips 4: teaching with patients	MJA 2004; 181 (3): 158-159
Teaching on the run tips 5: teaching a skill	MJA 2004; 181 (6): 327-328
Teaching on the run tips 6: determining competence	MJA 2004; 181 (9): 502-503
Teaching on the run tips 7: effective use of questions	MJA 2005; 182 (3):126-127
Teaching on the run tips 8: assessment and appraisal	MJA 2005; 183 (1): 33-34
Teaching on the run tips 9: in-training assessment	MJA 2005; 183 (1): 33-34
Teaching on the run tips 10: giving feedback	MJA 2005; 183 (5): 267-268
Teaching on the run tips 11: the junior doctor in difficulty	MJA 2005; 183 (9): 475-476
Teaching on the run tips 12: planning for learning during clinical attachments	MJA 2006; 184 (5): 238-239
Teaching on the run tips 13: being a good supervisor — preventing problems	MJA 2006; 184 (8): 414-415
Teaching on the run tips 14: teaching in ambulatory care	MJA 2006; 185 (3): 166-167

APPENDIX III

IMPLEMENTATION GUIDE

III.1. ESSENTIAL REQUIREMENTS FOR SUCCESSFUL IMPLEMENTATION OF THE CLINICAL TRAINING PROGRAMME

III.1.1. Programme management

On the level of an individual resident, the concept of clinical training can be relatively simple. However as a programme begins to involve many individual residences spread over a number of medical facilities, it grows in complexity and importantly it also needs clear assessment standards which need to be established and maintained[9]. This calls for a defined management structure.

This structure would normally be most effective on a national level[10] and usually needs to be placed within an established body or institution (such as a professional body for example). Relatively few countries have developed structures for clinical training currently in place. To assist in cases with limited existing management structures and limited resources, external assistance is advocated.

III.1.1.1. National

The programme should be recognised by a national authority such as the Medical Physics Professional Body, the Ministry of Health, the Ministry of Education or the National Atomic Energy Authority. The national authority is referred to as the ***National Responsible Authority*** (NRA) in this appendix.

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[9] See Appendix V Assessment criteria, page 161.
[10] Regional clinical training programmes might also be possible in some circumstances

The National Responsible Authority provides **formal recognition** of the qualification "Nuclear medical physicist" (or equivalent) and the requirements to become one.

The programme should be managed by a ***National Steering Committee*** comprising of representatives from the relevant Medical Physics Professional Body (where one exists) and other relevant interest groups and stake holders (such as Ministry of Health, Universities, Radiation protection authority, Allied professional societies etc.). It is highly recommended that the professional body should form the majority of members in the Committee.

In managing the programme the National Steering Committee must:

- Appoint a ***National Programme Coordinator*** to oversee the implementation of the project (appointment of several Programme Coordinators may be justified in large countries where regional coordination is necessary). The National Programme Coordinator should, ideally, be a person engaged in the practice of nuclear medicine physics.
- Establish a ***Support Group*** of individuals who agree to assist with Resident training. The support group may include nuclear medicine physicians, nuclear medicine physicists and personnel from educational institutions. Ideally, at least one nuclear medicine physicist who is external to the country should be a member of the support group.
- Ensure that guidelines for participation in the clinical training programme are strictly followed by both the clinical departments and the Residents.
- Ensure that standards for assessment are set and maintained
- Maintain records of Residents' progress.
- Issue certificates that provide an accurate record of a Resident's performance.
- Implement an annual survey of departments and Residents of progress of the training programme.
- Report to the external coordinator on progress of the programme.
- Develop a process for appeals and complaints.
- Ensure that the programme is financially viable. Ideally the employer and or government authorities benefiting from the improvement in the medical physicist workforce resulting from the clinical training should contribute financially to the programme.

In regard to maintaining of assessment standards the NSC should:

- Review all '**competencies addressed**' in the guide (Appendix IV) to determine if each competency is consistent with the required physics practice in nuclear medicine in the country. This can be done by specifying the appropriate '**level of competency achieved**'.
- Review and authorise the '**recommended items of training'** in the sub-modules to allow items to be added, deleted or altered upon advice.

The National Responsible Authority, having been assured that the National Steering Committee has fulfilled its responsibilities outlined above, should provide formal recognition of the qualification awarded.

III.1.1.2. External

One form of external assistance involved the piloting in selected countries for a trial period of several years. For these pilot programmes an external management structure has been formed to coordinate external support and to oversee the general conduct of the programme. The external management structure includes an external coordinator and external reviewers.

The external coordinator may assist the programme in the following ways:

- Review the entry qualifications of applicants for the training programme;
- Consider Resident numbers in relation to department resources including arrangements for supervision of the Resident(s);
- Review Residents' Progress;
- Coordinate the use of external reviewers;
- Consider and deal with issues raised by the external reviewers;
- Consider difficulties encountered and recommend remedial action to be taken;
- Provide advice to the National Programme Coordinator and National Steering Committee;
- Coordinate the assessment of the programme and compile statistics on the programme on an annual basis;
- Promote the sustainability of the national clinical training programme.

The external coordinator will work closely with the National Programme Coordinator and National Steering Committee to ensure the smooth operation and success of the programme.

The role of the external reviewers may include:

- Monitoring of the progress of individual Residents;
- Reviewing a Resident's work plan;
- Liaising with clinical supervisors;
- Reviewing items of assessment of a Resident;
- Giving presentations to medical physicists and Residents.

III.1.2. Basic requirements for departments where residents are located

III.1.2.1. Clinical Supervisor

The department must provide any Resident with a supervisor who is clinically competent in nuclear medicine physics. The number of residents in a department should normally not exceed the number of clinically competent medical physicists in that department. More detail concerning the requirements for supervision are provided below (section III.5).

III.1.2.2. Resources

It is important that the Resident is trained in the full range of a medical physicist's duties and hence a department participating in the training programme must have:

- Gamma camera / SPECT or SPECT/CT;
- Dose calibrator, probes and counters;
- Phantoms and calibration sources;
- Survey meters and, contamination probes.

The department must also have on-site or be prepared to rotate Residents to other departments with:

- Nuclear medicine therapy services.

It would also be advantageous to have access to

- PET or PET/CT;
- DXA unit.

III.1.2.3. Clinical service

The Resident must practice in a department that offers a full range of nuclear medicine services and which employs medical practitioners trained in nuclear medicine.

III.2. ENTRY REQUIREMENTS FOR RESIDENTS

It is expected that residents in this programme:

- have a university degree in physics, engineering or an equivalent physical science;
- should have an appropriate academic qualifications in medical physics (or equivalent) at the postgraduate level, or be enrolled in a suitable post graduate programme;
- should be employed as a medical physicist and working in a nuclear medicine clinical environment.

  Note: Alternative entry requirements may be approved in consultation with the external coordinator during the pilot process.

III.3. REQUIREMENTS FOR SUPERVISION OF RESIDENTS

A suitably qualified and experienced Clinical Supervisor should be appointed by a department seeking to participate in the RCA pilot of the clinical training programme. The supervisor should be a person working in the same department as the Resident. Participation of the Resident in the training programme and involvement of the department must be approved by the responsible medical specialist (including a guarantee that the Resident will have the necessary access to equipment).

The supervisor should:

- Have a commitment to the programme;
- Be available for consultation with the Resident when needed;
- Assist the Resident with access to equipment and all aspects of their training programme;
- Maintain links with the National Programme Coordinator to access national resources if required.

Although supervision by a person with experience in teaching is desirable, it is recognised that such a person may not always be available on-site. The role of the supervisor is to facilitate the resident's progress rather than necessarily to provide individual advice on all aspects of the training content. It is recommended that the supervisor attend a relevant train-the-trainer programme in clinical supervision. More detail of the roles and responsibilities of the Clinical Supervisor are provided in Appendix II *Handbook for Clinical Supervisors.*

III.4. ELEMENTS OF THE TRAINING PROGRAMME

III.4.1. The Guide

The clinical training guide for medical physics specializing in nuclear medicine includes eleven modules each containing a number of sub-modules. The modules

- Define a unified portion of clinical knowledge or experience and provide detailed content.
- Can be undertaken in any order and with more than one module undertaken at a time.
- Provide recommended items of training.

III.4.2. Items of Assessment

See Appendix 1.9

III.4.3. Supplementary appendices to assist the resident

These include:

- A Resident's Handbook
- A sample Logbook may be obtained from the external coordinator.
- A Logbook is recommended but not obligatory and is not included in the assessment process. If used, the Logbook is maintained by the Resident and contains a record of training experiences with comments as to difficulties experienced and positive learning outcomes. The form of the record is up to the Resident's discretion and could be in electronic or hardcopy form.

III.4.4. A Handbook for clinical supervisors

Designed to assist Clinical Supervisors in understanding and implementing the roles and responsibilities of the position.

III. 4.5. Implementation manual

This appendix.

APPENDIX IV

CLINICAL TRAINING GUIDE

INTRODUCTION

This IAEA Guide to Clinical Training of Medical Physicists specializing in nuclear medicine is divided into eleven modules. Each module defines a unified portion of clinical knowledge or experience.

The eleven modules are:

Module 1: Clinical Awareness

Module 2: Radiation Protection

Module 3: Research, development and teaching

Module 4: Professional Development and Management

Module 5: Equipment procurement, acceptance testing and commissioning

Module 6: Radioactivity measurements and internal dosimetry

Module 7: Quality control of nuclear medicine equipment

Module 8: Radionuclide therapy using unsealed sources

Module 9: Clinical computing and networking

Module 10: Clinical applications

Module 11: Preparation and quality control of radiopharmaceuticals

Modules 2 and 5–11 (highlighted) are considered as core modules.

The modules are further divided into sub-modules which address particular competencies. The sub-modules to be undertaken and the level of competency required to be achieved in **each sub-module** have been determined by the Responsible National Authority, or its delegate. You should refer to the Appendix V "*Competency Assessment"* to determine the levels required.

The modules and sub-modules are presented in tabular form. The table for each module includes:

- An objective
- Expected time commitment to the module (note this is a guide only. Particular Resident's may take more or less time to acquire the level of competency expected in particular modules).
- A core and supplementary reading list

The table for each sub-module includes:

- An objective for that sub-module
- An indication of pre-requisite knowledge required (if any) for the module
- The competency or competencies addressed in the sub-module
- Core knowledge
- Recommended elements of training
- Knowledge sources.

There are a total of 129 competencies, consisting of 66 knowledge and 63 skill based competencies included in the sub-modules. The modules and sub-modules can be undertaken in any order and with more than one module undertaken at a time.

Assessment of competencies should be performed using the assessment matrix for each sub-module provide in the appendix cited above.

The guide has been designed to be relevant for all modalities irrespective of the level of equipment complexity in use in the country. This has been done (i) to allow all countries undertaking clinical training to use a uniform national standard determined by their particular equipment types, and (ii) to reduce the effect of obsolescence as equipment technology changes. Where appropriate the national steering committee (NSC) should determine the 'level of competency achieved' for a competency and the type of unit(s) specified within a competency. Further the NSC can authorise changes to the 'recommended elements of training' that might be suggested.

	MODULE 1- CLINICAL AWARENESS
Objective	**To provide the resident with clinical knowledge and experience related to Nuclear Medicine**
Expected Duration	5% of total time
Sub-Modules	1.1 Essential anatomy and physiology for the nuclear medicine physicist 1.2 Basic principles of radiation biology and epidemiology 1.3 Clinical activities and factors that affect patient care
Core Reading	[1] BUSHBERG, J.T., SEIBERT, J.A., LEIDHOLDT, E.M.J., BOONE, J.M., The Essential Physics of Medical Imaging, 2nd Ed edn, Williams and Wilkins. (2002). [2] POWNSER, R.A., POWNSER, E.R., Essentials of Nuclear Medicine Physics, 2nd edn, Blackwell Science, Malden, USA (1998).
	Module 1 – Clinical Awareness
	Sub-module 1.1 – Essential Anatomy and Physiology for the Nuclear medIcine Physicist
Objective	To gain sufficient knowledge of anatomy and physiology to be able to communicate effectively with medical personnel
Prerequisite	None
Competencies Addressed	An understanding of (a) anatomy and physiology as seen on nuclear medicine images and in dynamic studies. (b) basic knowledge of anatomy and physiology as seen on other types of medical images The ability to discuss with nuclear medicine specialist the important features of diagnostic images
Core Knowledge	(1) Identify difference in image forming processes needed to produce various medical images (2) Typical anatomy and physiology related to nuclear medicine static, SPECT, whole body and dynamic imaging, PET (where available) (3) Typical anatomy on radiology images or other dynamic imaging modalities, e.g., echocardiography and blood flow in MRI

Recommended Elements of Training	• Discuss anatomy and physiological aspects of static, SPECT, whole body and dynamic nuclear medicine images with nuclear medicine specialist • Discuss various aspects of anatomy and physiology in medical images with medical staff including, but not limited to, radiologists, oncologist and other physicians. • Identify anatomy in other medical images. • Display nuclear medicine images and dynamic examinations properly • Appreciate physiological function in other dynamic imaging modalities, e.g., echocardiography and blood flow in MRI
Knowledge resources	[1] BUSHBERG, J.T., SEIBERT, J.A., LEIDHOLDT, E.M.J., BOONE, J.M., The Essential Physics of Medical Imaging, 2nd Ed edn, Williams and Wilkins. (2002). [2] DORLANDS, Dorlands Illustrated Medical Dictionary. [3] ELAIN, M., HOEHN, K., Human Anatomy and Physiology, 7th edn, (2006). [4] POWNSER, R.A., POWNSER, E.R., Essentials of Nuclear Medicine Physics, 2nd edn, Blackwell Science, Malden, USA (1998). [5] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values, ICRP Publication 89, Vol 32 No 3-4, Pergamon Press, Oxford and New York (2002).
	Module 1- Clinical Awareness
	Sub-module 1.2 Basic Principles of Radiation Biology and Epidemiology
Objective	To understand the basic radiation biology underpinning nuclear medicine imaging
Pre Requisites	None
Competencies Addressed	An understanding of the basic principles of radiation biology and epidemiology**.**
Core knowledge	Radiation biology • Basic cell biology • Track structure, LET and absorbed dose • RBE and Quality Factors • Equivalent dose and Radiation Weighting Factors • Effective dose and Tissue Weighting Factors • Cellular responses, DNA repair and cell survival/death • Oxygen effect • Stochastic and deterministic effects • Acute and late biological responses

	• Risk models and quantitative radiation risks • Doses and risks in nuclear medicine • LNT and uncertainties at low doses • Non-targeted effects (bystander responses & genomic instability) Epidemiology • Epidemiologic studies: case control and cohort studies • Odds ratio, relative risk ratio
Recommended Elements of Training	• Demonstrate understanding of factors affecting relative biological effect of different types of radiation • Demonstrate an understanding of mechanisms of radiation induced damage on the cell • Demonstrate an understanding of the terms used in epidemiology • Demonstrate an understanding of different dose-risk models • Demonstrate an understanding of the terms used in risk assessment
Knowledge resources	[1] HENNEKENS, C.H., BURING, J.E., MAYRENT, S.L., Epidemiology in Medicine, 1st edn, Lippincott Williams & Wilkins (1987). [2] SAHA, G.B., Physics and Radiobiology of Nuclear Medicine, 3rd edn, Springer Verlag (2006). [3] HALL, E., GIACCIA, A.J., Radiobiology for the Radiologist, 6th edn, Lippincott Wilkins & Williams, Philadelphia, USA (2006).
	Module 1 Clinical Awareness
	Sub-module 1.3: Clinical Activities and Factors that Affect Patient Care
Objective	To provide the resident with broad patient-related experiences and an understanding of the role of multidisciplinary professionals involved in or requesting nuclear medicine services.
Prerequisite	None
Competency addressed	An understanding of the factors that affect patient care An ability to discuss clinical activities and their relation to patient care in the following areas • Nuclear medicine • Radiology • Radiation oncology • Other areas.
Core Knowledge	• Need for patient care, rapport, privacy, and confidentiality during patient related experiences. • Appropriate professional conduct and ethical attitudes

	• Appropriate hygiene and infection control procedures • Effect of diagnostic imaging and radiotherapy on patient quality of life • Patient-staff interactions • Patient – nuclear medicine physicist interaction • Interactions, roles, and responsibilities of multi-disciplinary professionals involved in patient management.
Recommended Elements of Training	**Nuclear medicine** Exposure to the following patient-related clinical experiences: • Nuclear medicine imaging procedures • Preparation and administration of radiopharmaceutical • Radionuclide therapy During this time, the resident should: • Understand the patient work flow for a nuclear medicine procedure • Attend preparation of radiopharmaceutical • Attend reporting sessions in nuclear medicine over a number of weeks covering related modalities • Attend at least two clinical review meetings covering each of a number of organ systems (case review) • Attend some common diagnostic nuclear medicine procedures. • Demonstrate an understanding of the purpose of the typical procedures. • Note the reasons for the patient's admission and their conditions • Attend administration of radionuclide for therapy • Prepare a patient case study for a complex procedure such as a cardiac procedure • Study local and national regulations on confidentiality and handling of patient information. **Radiation Oncology** • Attend all phases of the radiotherapy process from a simulation through to patient treatment. • Examine the roles of imaging used in this above process (diagnosis, simulation, and treatment) whether the imaging modality is situated within radiation oncology or elsewhere. • Discuss the key differences in the application of identified imaging modalities in therapy compared to nuclear medicine **Radiology** • Observe some common diagnostic radiology procedures including interventional procedures • Discuss the role of CT in nuclear medicine imaging • Discuss the differences between, and relative advantages of, nuclear

	medicine and x-ray imaging • Discuss the dosimetry and protection differences between nuclear medicine and radiology (patient and staff) • Study the QC procedures used in radiology **Ultrasound** • Observe ultrasound imaging procedures (where ethically possible), including Doppler imaging • Discuss the differences between, and relative advantages of ultrasound and nuclear medicine **MRI** • Observe MRI procedures including functional studies • Discuss the difference between, and relative advantage of nuclear medicine and MRI **Other areas** • Discuss the problems and restrictions when nuclear medicine is used in operating theatre or ward • Study local regulations on hygiene and infection control
Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, AAPM Code of Ethics, AAPM, New York (2008). http://www.aapm.org/org/policies/details.asp?id=260&type=PP&current=true. [2] BUSHBERG, J.T., SEIBERT, J.A., LEIDHOLDT, E.M.J., BOONE, J.M., The Essential Physics of Medical Imaging, 2nd Ed edn, Williams and Wilkins. (2002). [3] The Journal of Nuclear Medicine' and 'Journal of Nuclear Medicine Technology' both publishes good review articles. Some of these are available free from their website. You can access these via http://www.snm.org

	MODULE 2- RADIATION PROTECTION
Objective	To develop key skills in radiation protection practice in a nuclear medicine department It should be noted that the tasks defined in this module, with the exception of 2.2, 2.3 and 2.6 may be also carried out by a Radiation Protection Officer (RPO). Local circumstances will dictate actual working arrangements
Expected Duration	15 % of total time
Sub-Modules	2.1 Monitoring radiation levels including personnel monitoring 2.2 Exposure from unsealed sources and the risk of contamination 2.3 ALARA and Radiation Safety Precautions in Nuclear Medicine 2.4 Risk assessment and advice to staff, patients and others regarding radiation risk 2.5 Areas designated for the use of unsealed radioactive material 2.6 Radiation shielding considerations in the design of new facilities 2.7 Regulatory controls and other guidance on the safe use of ionising radiation in nuclear medicine
Core Reading	[1] HENDEE, W.R., IBBOTT, G.S., HENDEE, E.G., Radiation Therapy Physics, 3rd edn, John Wiley & Sons, Inc. (2005). [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Applying Radiation Safety Standards in Nuclear Medicine, Safety Reports Series No. 40, STI/PUB/1207, IAEA, Vienna (2005). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1207_web.pdf. [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series, SF-1, IAEA, Vienna (2006). www-pub.iaea.org/MTCD/publications/PDF/Pub1273_web.pdf. [4] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, General principles for the radiation protection of workers, ICRP publication 75, Annals of the ICRP Volume 27/1, Pergamon Press, Oxford and New York (1997). [5] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The 2007 Recommendations of the ICRP. Annals of the ICRP vol 37 (2-4) Rep. 103 (2007). [6] MARTIN, A., HARBISON, S.A., An Introduction to Radiation Protection, 5th edn, Oxford University Press (2006). [7] MARTIN, C.J., SUTTON, D.G., Practical Radiation Protection in Healthcare, Oxford University Press, Oxford (2002).

	Module 2: Radiation Protection
	Sub-module 2.1: Monitoring Radiation Levels Including Personnel Monitoring
Objective	To be able to identify sources of radiation, to monitor radiation levels and analyse potential hazards
Prerequisite	None
Competencies Addressed	An understanding of (a) the principles of operation of equipment used for monitoring radiation levels in nuclear medicine. (b) the purpose, principles and operation of a personnel dosimetry program Ability to measure radiation levels and to perform quantitative measurement of contamination
Core Knowledge	• Identify external and internal radiation hazards • Quantify radiation hazards using survey meters, contamination monitors and wipe testing. • Identify radionuclides by type of emission, energy and half-life. • The theory, principles of operation, and limitations of personal monitoring • The basic operational quantities and their relationship to effective dose • Advise on the requirements for safe handling and storage of unsealed radioactive materials.
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency • Awareness of the local regulatory guideline on radiation protection in nuclear medicine • Prepare a protocol for a contamination survey, including: what is wiped, materials used, areas wiped, how are they measured, limits of action. • Prepare a protocol for an external exposure survey, including: where and when measurements are made, what instrument(s) are used, limits of action. • Carry out a radiation survey of a laboratory, including: o Inventory of the types and amounts of radio-isotope and radio-pharmaceutical entering the lab and any relevant properties (e.g. iodine is volatile) o Inventory of available radiation measuring instruments. Note the applications and limitations of each instrument. o Inventory of sealed sources, handling, storage and location

	○ Use of personal monitors: type, location, frequency of changing ○ Handling and storage of unsealed sources • Generate a written radiation survey report with appropriate recommendations. Prepare material for information to staff.
Knowledge Sources	[1] DELACROIX, D., GUERRE, J.P., LEBLANC, P., HICKMAN, C., Radionuclide and radiation protection data handbook 2nd edition (2002), Radiat Prot Dosimetry 98 1 (2002) 9-168. [2] DEPARTMENT OF ENVIRONMENT AND CONSERVATION (NSW), Radiation Guideline-1, monitoring devices. EPA, http://www.environment.nsw.gov.au/resources/radiation/devices.pdf. [3] TEMPERTON, D.H., GREEN, S., "Personal Monitoring", Practical Radiation Protection in Healthcare, (MARTIN, C.J.SUTTON, D.G., Eds), Oxford University Press, Oxford, (2002).
	Module 2: Radiation Protection
	Sub-module 2.2: Exposure from unsealed Sources and the Risk of Contamination
Objective	To demonstrate knowledge on the reduction of exposure from unsealed sources and how to handle spills and accidents
Pre Requisites	Awareness of the local regulatory guideline on radiation protection in nuclear medicine Sub-module 1.1 Clinical Awareness
Competencies Addressed	An understanding of methods to reduce exposure. The ability to (a) safely handle unsealed radioactive sources. (b) handle accidents and spills
Core Knowledge	• Identify locations or practices where radiation exposure could reasonably be reduced. • Estimate dose rates near patients and influence of patterns of close contact. • Implement measures to reduce non-essential contact with radioactive patients and other sources. • Decontaminate staff, machine and premises after a spill of radioactive material. • Estimate organ doses after contamination • Assess the level of contamination remaining after decontamination. • Implement measures to reduce exposure due to residual contamination. • Analyse misadministrations, make estimates of absorbed dose and provide guidance on improvement of practices. • Generate a written incident report.
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material • Make recommendations for assessment of staff following a spill. • Design training for staff, so that they act appropriately in the event of a spill.

	• Review the workflow of the Department from a radiation safety point of view. This should include: o receipt, storage and disposal of radioactive material o preparation and dispensing of radiopharmaceuticals o patient injection or administration procedures o patient movements before and after injection o patient scanning procedures • Conduct a radiation survey of the various areas in the Department (hot lab, patient waiting areas, scanning rooms etc.), noting in particular: o the availability and use of shields o whether the layout allows adequate distance from sources o whether work procedures allow minimal time near sources • Propose and justify reasonable changes to procedures, layout or shielding to reduce the radiation dose to staff, patients or members of the public. • Prepare general instructions for Department staff for contaminating and decontaminating following a spill. Describe additional tasks to assess residual contamination and formulate recommendations for remedial action (e.g. taping plastic over the contaminated floor area, replacing contaminated equipment etc.). • Review literature on procedures to estimate organ doses from contamination. • Note radiopharmaceuticals for which extra steps would be required, because of long half-life, increased likelihood of uptake or adverse biological characteristics. In each case, specify and justify the required steps. • Devise a system for maintaining an overview of spill incidents, including contributing factors and measures to prevent further incidents • Prepare a hypothetical incident report for: a major spill of iodine in the Hot Lab; a minor spill of gallium in a camera room.
Knowledge Sources	[1] CEMBER, H., JOHNSON, T.A., Introduction to Health Physics, 4th edn, McGraw-Hill, New York (2008). [2] DELACROIX, D., GUERRE, J.P., LEBLANC, P., HICKMAN, C., Radionuclide and radiation protection data handbook 2nd edition (2002), Radiat Prot Dosimetry 98 1 (2002) 9-168. [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Medicine Resources Manual, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1198_web.pdf. [4] Radiation Safety and Protection Plan (Manual) of the trainee's institution and the national regulations on radiation protection [5] STABIN, M.G., Radiation Protection and Dosimetry: An Introduction to Health Physics, Springer, New York, NY (2007). http://opac.library.usyd.edu.au/record=3563832.

	Module 2: Radiation Protection
	Sub-module 2.3: ALARA and Radiation Safety Precautions in Nuclear Medicine
Objective	To demonstrate knowledge on how to apply ALARA and radiation protection regulations in nuclear medicine clinical practice
Prerequisite	Sub -Module 2.1 Monitoring radiation levels including personnel monitoring Sub- Module 2.2 Exposure from unsealed sources and the risk of contamination
Competency addressed	An understanding of the application of the ALARA principle Ability to apply radiation protection regulations in clinical nuclear medicine practice
Core Knowledge	• Basic radiation protection Principle: Time, Distance, Shielding • Demonstrate knowledge of dose limits for occupational and public exposures and of typical radiation doses to health care workers and others in a well-managed practice • Design workflow and procedures so as to minimize the radiation dose to staff, patients, carers at home and members of the public. • Identify situations when extra precautions may be advisable, such as a breastfeeding patient or when the mother of a paediatric patient is pregnant • Develop precautions for a new procedure • Prepare local routines and Information Sheets for patients/carers for specific clinical applications, addressing such issues as periods of close contact with children, breast feeding and urinary incontinence.
Recommended elements of training	• Be reasonably familiar with the resource material recommended for this competency • Review the potential exposures from diagnostic nuclear medicine to staff in the Department, including Hot Lab staff, nurses, porters, technologists and medicos, and in the hospital. Note also the exposures to members of the public, including accompanying persons and other patients, including travel home by car or public transport. • Write a report from your observations with recommendations to reduce exposure. For any possible modifications which reduce dose, consider the disadvantages. Is the reduction in dose achieved by 'reasonable' means? • Choose a procedure involving ^{99m}Tc. Write out the workflow, including radiopharmaceutical dispensing, patient preparation and injection, scanning and patient movements. Estimate the dose rate for each occasion of exposure. This can be done by reading the literature or by taking some measurements. Inpatients, outpatients,

	accompanying persons, staff and members of the public should all be considered. • For each workflow step, describe and justify reasonable practices to minimize radiation dose, indicating who is being protected (e.g. technologist, nurse, patient, accompanying person). • Produce an Information Sheet for the patient and/or carers with recommendations for practices to minimize radiation dose. • Compare your conclusions with current recommendations (e.g. in the Department's Radiation Safety and Protection Plan). Comment on any differences. • Review recommendations from international organisations on handling of breast-feeding women.
Knowledge Sources	[1] CORMACK, J., TOWSON, J., FLOWER, M., "Radiation protection and dosimetry in clinical practice", Nuclear Medicine in Clinical Diagnosis and Treatment, (ELL, P.GAMBHIR, S., Eds), Churchill Livingstone (2004). [2] INSTITUTE OF PHYSICAL SCIENCES IN MEDICINE, Radiation Protection in Nuclear Medicine and Pathology Rep. 63 (1991). [3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, General principles for the radiation protection of workers, ICRP publication 75, Annals of the ICRP Volume 27/1, Pergamon Press, Oxford and New York (1997). [4] POCHIN, E., Nuclear Radiation: risks and benefits, Clarendon Press, Oxford (1985).
	Module 2: Radiation Protection
	Sub-module 2.4: Risk Assessment and Advice to Staff, Patients and Others Regarding Radiation Risk
Objective	To demonstrate knowledge on how to apply radiation protection regulations in nuclear medicine clinical practice
Prerequisite	Sub-Module 1.1 Clinical Awareness Sub-Module 3.1 Monitoring radiation levels including personnel monitoring Sub-Module 3.2 Exposure from unsealed sources and the risk of contamination
Competency addressed	An understanding of: (a) the methods for estimating effective dose to the patient from diagnostic nuclear medicine scans. (b) knowledge of the risks associated with radiation exposure. (c) the procedures for risk assessment. Ability to communicate risk or lack of risk in the context of dose, justification and relevant non-radiation risks

Core knowledge	• Relate occupational exposures in nuclear medicine to other occupational risks and to variations in natural background. • Assess the risk and recommend precautions for women who wish to continue working in nuclear medicine while pregnant • Determine the risks to patients of any age from the radiation exposure associated with their diagnostic nuclear medicine procedures, and relate these to other clinical risks • Able to communicate risk or lack of risk in context of dose, justification and optimization
Recommended elements of training	• Read, and be reasonably familiar with, the resource material recommended for this competency • Review material on risk assessment and communication of risk. • Write a formal response to the following requests for information. In each case, provide an estimate of effective dose, the corresponding risk, and one or more examples of a comparable exposure and/or a comparable risk. o for a concerned parent, whose 9-year old child has been referred for a renal scan (dose to the child). o for a pregnant mother, whose 5-year old child has been referred for a bone scan (dose to the mother/foetus) o for a pregnant registrar who is concerned about working in the stress room o for an ultrasonographer who is concerned about scanning a nuclear medicine patient o for a patient who had a diagnostic nuclear medicine procedure when she was unaware that she was pregnant at the time, including comment on the foetal dose, any likely consequences and comparison with the normal risks of pregnancy.
Knowledge Sources	[1] CORMACK, J., TOWSON, J., FLOWER, M., "Radiation protection and dosimetry in clinical practice", Nuclear Medicine in Clinical Diagnosis and Treatment, (ELL, P.GAMBHIR, S., Eds), Churchill Livingstone (2004). [2] FISCHHOFF, B., Risk perception and communication unplugged: twenty years of process, Risk Anal 15 2 (1995) 137-45. [3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Pergamon Press, Oxford and New York (1991). [4] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Radiation Dose to Patients from Radiopharmaceuticals ICRP Publication 53 - Addendum 5, 6 and 7, Pergamon Press, Oxford and New York (2001). [5] http://www.orau.org/ptp/infores.htm#dosimetry [6] http://www.orau.org/ptp/infores.htm#dosimetry

	Module 2: Radiation Protection
	Sub-module 2.5: Areas Designated for the Use of Unsealed Radioactive Material
Objective	To demonstrate knowledge about the general design requirements of the department
Prerequisite	Sub-module 2.1 Monitoring radiation levels including personnel monitoring
Competency Addressed	Familiarity with (a) the designation of areas of the workplace associated with protection from unsealed radioactive material (b) the different radionuclide decay processes. Ability to manage a radioactive waste store for the sources used in a nuclear medicine department
Core Knowledge	• Grade a laboratory area depending on the radionuclides, activity and operations according to the respective regulatory body. • Design areas and specify construction requirements suitable for o Preparation, dispensing and administration of radiopharmaceuticals o A radioactive waste store o CT installations in combination with radionuclide imaging • Understand the difference in requirements for Controlled and Supervised areas.
Recommended Elements of Training	• Be familiar with the resource material recommended for this competency. • Determine the grading of a hot lab as High, Medium or Low, from the maximum quantities of radionuclides and the operations as per the regulatory rules. Assume both diagnostic (including some FDG for PET) and therapy radiopharmaceuticals will be used. Blood cell labelling will not be required. • Prepare a set of specifications for the hot lab, including o Surface finishes o Airborne contamination o Segregation of radionuclide and paper work o Security of access and stores o Local shielding o Any other features you think would be required • Estimate the lead thickness required for the walls and door of a 1x1x1m cupboard to be used for soiled linen contaminated with up to 5 GBq of I-131. The cupboard is immediately behind an area occupied by office staff. The door opens onto a corridor.

Knowledge Sources	[1] CEMBER, H., JOHNSON, T.A., Introduction to Health Physics, 4th edn, McGraw-Hill, New York (2008). [2] INSTITUTE OF PHYSICAL SCIENCES IN MEDICINE, Radiation Protection in Nuclear Medicine and Pathology Rep. 63 (1991). [3] NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Structural shielding design and evaluation for medical use of x-rays and gamma rays of energies up to 10 MV, NCRP Rep. 49, Bethesda, MD, USA. (1976). www.ncrppublications.org.
	Module 2: Radiation Protection
	Sub-module 2.6: Radiation Shielding Considerations in Design of New Facilities
Objective	To acquire knowledge on facility design for radiation protection
Pre-requisites	Sub-Module 3.2 Exposure from unsealed sources and the risk of contamination Sub-Module 3.5 Areas designated for the use of unsealed radioactive material.
Competency Addressed	An understanding of the principles and requirements of shielding design for radionuclides energies being used for diagnostic Nuclear Medicine purposes. Familiarity with shielding requirements for PET, SPECT installations in combination with other imaging (e.g. CT) modalities The ability to design satisfactory radiation shielding for all types of nuclear medicine equipment
Core Knowledge	• Principles o Radiation dose units and metrics applicable to shielding design o Primary Radiation; attenuated and un-attenuated o Secondary Radiation; scatter and leakage o Transmission of primary and secondary radiation through patients, imaging components and barriers • Regulatory Requirements and Guidelines o Local legislation and guidance applying to the design of Nuclear Medicine facilities o Designation of controlled and supervised areas o Dose limits for workers and members of the public o Dose constraints and shielding design goals • Shielding concepts o Concepts of primary and secondary barriers o Concepts of workload including effect of technique factors, effect of patient numbers, effect of future changes in workload, equipment design, and usage, e.g., change from gamma camera room to a PET/ CT room which need specific

	shielding for 511 keV. o Concepts of occupancy and impact of the occupancy of surrounding areas on shielding design o Concept of cross-talk between equipment and other disturbances of measurement due to radioactivity in surrounding rooms. • Materials o Attenuation properties of materials o Substitute materials and impact on shielding effectiveness o Common building materials and techniques • Shielding Requirements o Determination of radiation dose at barrier from workload data o Calculation of required transmission o Specification of required materials • Assessment of shielding o Visual monitoring during construction o Use of radionuclides o X ray measurement (for SPECT/CT, PET/CT)
Recommended Elements of Training	• Carry out workload assessment – taking into account both examination technique & patient numbers • Determine occupancy of surroundings of a PET/CT room • Perform the shielding calculation and assumptions for the establishment of PET/CT. Depending on the situation, a PET/CT system may require moderate to heavy shielding. Hot lab and injection rooms should have appropriate shielding • Assess the effect on shielding options of equipment location and orientation • Assess the effectiveness of shielding and errors in measurements. • Document effect of changes in workload, equipment usage, equipment orientation or equipment design on shielding requirements • Do an assessment of shielding, visual monitoring during construction. Perform Documentation of complete assumptions, design, and specifications for future reference, and maintenance.
Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, AAPM Task Group 108: PET and PET/CT Shielding Requirements, AAPM Rep. 108, New York (2006). http://www.aapm.org/pubs/reports/RPT_108.pdf. [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Shielding, http://www.rpop.iaea.org/RPOP/RPoP/Content/Documents/TrainingRadiology/Lectures/L12_Shielding_WEB.ppt. [3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Conversion coefficients for use in radiological protection against external radiation, ICRP publication 74. Ann ICRP 1997 (77) 2, Pergamon Press, Oxford and New York (1997). [4] NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Structural Shielding Design for Medical X-Ray Imaging Facilities, NCRP Rep. 147, Bethesda, MD, USA.

	(2004). www.ncrppublications.org. [5] ANDERSON, J.A., MATHEWS, D., Site Planning and Radiation Safety in the PET Facility, Place, Published http://www.aapm.org/meetings/02AM/pdf/8418-39272.pdf.
	Module 2: Radiation Protection
	Sub-module 2.7 Regulatory Controls and Other Guidance on the Safe Use of Ionising Radiation in Nuclear Medicine
Objective	To understand and advise on all aspects of regulatory compliance
Prerequisites	Sub-module 2.3: ALARA and Radiation Safety Precautions in Nuclear Medicine
Competency Addressed	An understanding of the local regulatory requirements for Nuclear Medicine The ability to advise on local, regional, and national radiation protection and safety legislation
Core Knowledge	• The regulatory controls on the safe use of ionizing radiation in nuclear medicine in the trainee's own location • Create and maintain radiation records for a Nuclear Medicine Dept. that conform with regulatory requirements and usual standards of practice including o Personnel dose o Radiation licences and registrations o Radiation incidents o Radioactive materials including wastes. • Apply the guidelines relevant to nuclear medicine as issued by the local regulatory authority and professional organisation • Assess and report on the Radiation Safety Program in the trainee's institution
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency • Summarize the radiation control legislative requirements in your location including: o Responsibilities of employers and employees including information on radiation safety o Licensing and supervision for anyone working in nuclear medicine including physicians, registrars, technologists/ trainees, service engineers, scientists and postgraduate students. o Include any requirements relating to the use of hybrid CT imaging systems o Limits on radiation dose resulting from working with radiation, working near radiation, or as a member of the

	general public o Radiation monitoring of persons working in nuclear medicine o Area monitoring o Calibration of radiation monitoring devices o Registration of nuclear medicine facilities, radioactive sources whether sealed or unsealed, x ray apparatus including hybrid CT o Purchase of radioactive material o Disposal, loss or theft of radioactive material o Investigation and reporting of radiation accidents o Exposure to humans for research purposes o Contamination of the environment o Maintaining or destroying radiation records o Discharge of radioactive material to air or sewer o Transport of radioactive materials • In your own Department, review the current record keeping system related to: o personnel dosimetry o licensing for use of radioactive materials o incident reporting o inventory control and waste disposal of radioactive material • For each of these areas, consider possible improvements. If necessary, design and implement an appropriate system which will facilitate identification of potential problems such as lost sources, repeated spills, excessive dose to a particular person, etc. • Write a report on the record system • In your own Hospital, report on the radiation safety program including: o Description of any committees and duties of anyone who has a radiation safety role. Draw a diagram of lines of management and reporting o How are radiation accidents reported and investigated o What would be a 'high' dose reading on a personal dosimeter in nuclear medicine and what would be done about it o How are staff informed about radiation safety o How are safety rules drawn up and enforced
Knowledge Sources	[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection in Nuclear Medicine Part 9 Quality Assurance, http://rpop.iaea.org/RPOP/RPoP/Content/Documents/TrainingNuclearMedicine/Lectures/RPNM_Part09_qa_WEB.ppt#1 [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series, SF-1, IAEA, Vienna (2006). www-pub.iaea.org/MTCD/publications/PDF/Pub1273_web.pdf. [3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The 2007 Recommendations of the ICRP. Annals of the ICRP vol 37 (2-4) Rep. 103 (2007).

	MODULE 3 - RESEARCH, DEVELOPMENT AND TEACHING
Objective	To develop key skills in research, development and teaching in Nuclear Medicine Physics.
Expected Duration	5% of overall time.
Sub-Modules	3.1. Research and Development 3.2. Teaching
Core Reading	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, A guide to the teaching of clinical radiological physics to residents in diagnostic and therapeutic radiology, AAPM Rep. 64, New York (1999). http://www.aapm.org/pubs/reports/rpt_64.PDF. [2] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Quality assurance for clinical trials: A primer for Physicists. 2004 AAPM Rep. 86, New York (2004). http://www.aapm.org/pubs/reports/rpt_86.PDF. [3] ICH/CPMP, Good Clinical Practice : Consolidated Guidelines, International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use Rep. E6 (R1) (1996). http://www.ich.org/cache/compo/276-254-1.html.
	Module 3 - Research, Development and Teaching
	Sub-module 3.1-Research and Development
Objective	To develop the ability to perform research in an area of relevance to nuclear medicine physics either individually or as a member of a multi-disciplinary research team.
Pre-requisites	None
Competencies Addressed	An understanding of processes of scientific research including the role of ethics review, statistical analysis, and the publication process. The ability to carry out research and development in nuclear medicine physics in cooperation with nuclear medicine physicians, diagnostic medical physicists, radiation oncology medical physicists and other professionals.
Core Knowledge	(1) Understanding of • The role of ethics in research involving human and animal subjects including radiation related subjects

	• The application of statistics to experimental design, formulation of hypotheses, and data analysis (including ROC analysis where appropriate) • The format of scientific papers • The peer-review process of research grant applications and scientific publications (2) Awareness of appropriate international journals in nuclear medicine, medical physics, and associated fields of research
Recommended elements of training	Design a research project including: • Identify an area for research, including the specific question which is being asked, in consultation with other professionals such as nuclear medicine physicians. • Formulate hypotheses. • Review the literature in the area effectively and critically, using appropriate databases e.g., MedLine, PubMed and Scorpus, and provide this in a written report (including the clinical benefits of the research or development). • Continually monitor current advances in research and development in the chosen area of research. • Determine a plan for a research project including milestones, necessary experiments, and analysis. • Consult with statistician or epidemiologist as required. • Evaluate the ethical issues involved against national criteria, including radiation issues, and make the necessary application to an appropriate ethics committee (also known as a human studies committee [HSC] or institutional review board [IRB]) if necessary. • Evaluate required resources including time, personnel, and equipment. Manage a budget for a small research project Peer review of results: • Present and defend results at the departmental level • Present results at national or international conference • Publish in a peer-reviewed journal Building on research initiatives • Write a simple research grant application in conjunction with nuclear medicine physicians or other experienced staff, including a response to comment from the review process. • Participate in a multidisciplinary research team by contributing medical physics knowledge and skills, such as providing dosimetry support. • Provide dose calculations and risk estimates, including comparisons to other risks from ionizing radiation, for use by the ethics committee (HSC or IRB) for a proposed project involving medical internal radiation dosimetry to human subjects.

Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Quality assurance for clinical trials: A primer for Physicists, AAPM Rep. 86, New York (2005). http://www.aapm.org/pubs/reports/rpt_84.PDF. [2] ARPANSA, Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes, Radiation Protection Series Rep. 8, ARPANSA. http://www.arpansa.gov.au/rps8.htm. [3] ICH/CPMP, Good Clinical Practice : Consolidated Guidelines, International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use Rep. E6 (R1) (1996). http://www.ich.org/cache/compo/276-254-1.html. [4] ICH/CPMP, Statistical Principles for Clinical Trials, International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use Rep. E9 (1998). http://www.ich.org/cache/compo/276-254-1.html. [5] http://www.nhmrc.gov.au/ethics/human/issues/trials.htm [6] http://www.tga.gov.au/docs/html/ich13595.htm. [7] RAVINDRAN, C., Ethics in Biomedical Research, Calicut Medical Journal **6** 2 (2008). [8] WOODWORD, M., Epidemiology: Study Design and Data Analysis, 2nd edn, Chapman & Hall/CRC (2005). [9] WOOLFE, J., How to write a PhD Thesis, http://www.phys.unsw.edu.au/~jw/thesis.html [10] WORLD HEALTH ORGANIZATION, Operational Guidelines for Ethics Committees That Review Biomedical Research, Geneva (2000).
	Module 3 - Research, Development, and Teaching
	Sub-module 3.2 - Teaching
Objective	To develop the skills required to be an effective educator and mentor in nuclear medicine physics
Prerequisites	None
Competencies Addressed	An understanding of the general principles of effective teaching Ability to teach principles and methods of nuclear medicine physics.
Core Knowledge	Understand the general principles of effective teaching including: • teaching method and strategies appropriate to the group size, needs, interests, and backgrounds of the audience • mechanisms of student feedback and assessment strategy • provision of necessary instructional material for the student • preparation of teaching material • review of teaching processes

Recommended elements of training	• Attend a general course (often available at national or international nuclear medicine meetings) on how to teach • Attend refresher courses at the SNM, ARCCNM and EANM meetings to observe both medical physicists and nuclear medicine physicians teaching various topics • Teach medical physics, technology, and radiation topics (including radiation safety) to different audiences. Suggested examples include: (1) Teaching to medical physicists, junior physicists, or other technically orientated staff (2) Teaching to nuclear medicine staff and residents (3) Teaching radiation safety to nurses or other paramedical staff (e.g., departmental secretaries) (4) Teaching technologists to carry out quality control of a specific nuclear medicine equipment
Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, A guide to the teaching of clinical radiological physics to residents in diagnostic and therapeutic radiology, AAPM Rep. 64, New York (1999). http://www.aapm.org/pubs/reports/rpt_64.PDF. [2] SAHA GB., Physics and Radiobiology in Nuclear Medicine. 2nd edn, Springer. (2001). [3] Teaching radiology residents resource, http://www.blueskybroadcast.com/Client/AAPM_Annual05/aapm_a74_panel/launch.html. [4] AAPM ONLINE EDUCATIONAL, library, http://aapm.org/meetings/virtual_library/. [5] AAPM ONLINE EDUCATIONAL, Continuing education, http://aapm.org/education/ce/category.asp...

	MODULE 4 – PROFESSIONAL DEVELOPMENT AND MANAGEMENT
Objective	To develop knowledge and competencies relating professional aspects of the nuclear medicine physicist's roles and responsibilities.
Expected Duration	5% of total time
Sub-Modules	4.1 Professional Awareness 4.2 Communication 4.3 Quality Management 4.4 Clinical audit
Core Reading	[1] NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL, Communicating with patients: advice for medical practitioners, (2004), http://www.nhmrc.gov.au/publications/_files/e58.pdf. [2] VENABLES, J., Communication Skills for Engineers and Scientists, 3rd edn, Institute of Chemical Engineers (2002).
	Module 4 – Professional Development and Management
	Sub-module 4.1: Professional Awareness
Objective	To demonstrate an understanding of, and participate in (if possible), activities related to professional awareness.
Prerequisite	None
Competencies Addressed	Demonstrate an understanding of professional issues. Contribution to professional body activities.
Core Knowledge	• An understanding of departmental staff structure and local career opportunities for medical physicists. • An appreciation of the structure and activities of the local professional medical physics organisation, and its relationship to overseas peak bodies. • An understanding of the ethical, legal and intellectual property issues faced in the workplace by the medical physicist. • An understanding of the term CPD and how it operates.
Recommended Elements of Training	**Career Planning** • Achieve an understanding of the scope of practice and career structure of nuclear medicine physicists. • Achieve an understanding of the opportunities and restrictions in career progression. • Draw a tree diagram summarising your department's staff structure, including your position. • Define your own career plan.

	Professional Organisation Activities • Demonstrate an awareness of your professional organisation including its aims, structure, key office bearers and administrative staff. • Attend and actively participate in professional activities. • Regularly review websites of medical physics professional organisations world-wide • Demonstrate an awareness of topical issues affecting your profession and your professional organisation. • Demonstrate an awareness of other allied organisations (e.g. Nuclear medicine physicians and nuclear medicine technologists) and locate the relevant websites. • Demonstrate of the awareness of international agencies and professional bodies as related to nuclear medicine physics. • Demonstrate an awareness of important professional journals in and related to medical physics and nuclear medicine, and regularly read relevant papers. **Professional Issues** **(i) Ethics** • Demonstrate an understanding of your professional organisation's and hospital's policies and procedures on professional and clinical ethics. • Demonstrate an awareness of the code of conduct and mission statement for your professional organisation and hospital. • Understand the local and/or national requirements for ethics clearance for clinical research projects. • Understand the requirements of privacy of staff and patient information. **(ii) Legal Issues** • Outline the objectives, definition and requirements of/for legal issues at your institution/s (e.g. hospital and university if relevant) and in your state and country as related to nuclear medicine medical physicists. This should include the policies on conflict of interest and legislation and regulatory matters. • Outline local and/or national requirements of radiation incident reporting. • Awareness of data protection legislation. **(iii) Intellectual Property** • Understand the types of intellectual property. • Outline the objectives, definition and requirements of/for intellectual property at your institution/s (e.g. hospital and university if relevant). • Outline ownership of material produced as a result of your research at your institution. • Demonstrate an awareness of vendor intellectual property requirements in the workplace, including software licensing and warranties.

	Continual Professional Development (CPD) • Demonstrate an awareness of the objective of CPD. • Demonstrate an awareness of legislation and/or professional organisation requirements for CPD.
	Module 4 – Professional Development and Management
	Sub-module 4.2: Communication
Objective	To be a good communicator within a multi-disciplinary team, with patients and the general public.
Prerequisites	None
Competencies Addressed	Demonstrate a high level of oral and written communication and interpretation skills The ability to communicate with clinicians and apply physical principles to clinical problems
Core Knowledge	• How to communicate effectively within a multidisciplinary team, both orally and in writing.
Recommended Elements of Training	**Oral Skills** • Attend a course on o Oral presentation competencies, o Mentoring competencies, and/or o Conducting professional meetings. • Actively participate in physics department meetings (chair a meeting if possible). • Actively participate in Department technical meetings. • Scientific presentation at meeting of Medical Physicists, multi-disciplinary professionals or an audience containing members of the general public. • Medical Physics tutoring for other Nuclear Medicine professionals. Examples include Radiation Safety lectures and tutorials to Nuclear Medicine Registrars. • Actively participate in project progress meetings during equipment commissioning. • Presentation of research results at a national and/or international conference/meeting. • Provide accurate, clear, clinical medical physics advice regarding optimization of nuclear medicine procedures to other Nuclear Medicine Professionals. **Written Skills** • Demonstrate understanding of professional issues such as legal consequences of information documented and forwarded via email, confidentiality, sensitivity and permission to use data. • Demonstrate understanding of appropriate format and style of professional written communication, including email, memos and letters. • Keep a logbook

	• Write an example of a professional letter, email and memo that you could send to a key manager in the Nuclear Medicine Department addressing a medical physics issue. • Write a brief technical report on the optimisation of a diagnostic procedure. • Write a business case to management regarding the case for new or a replacement of nuclear medicine equipment. • Write or review a protocol (new or revised) for a quality control process in the Department. • Write a progress and/or final report for commissioning of a new item of nuclear medicine equipment in a Nuclear Medicine Department. **Comprehension Skills** • Participate in department meetings to review journal papers • Present a review of an international technical protocol to Physics Department **Communication** • Investigate the roles of other medical and allied health professions in the health system, and especially where those professions involve imaging. • Talk with work colleagues, to understand their point of view, and to help them understand yours. **Consultation and Support** • Communicate with the clinician in terms they can understand in their specialty • Listen to a non-nuclear medicine problem posed by a clinical colleague • Use your general physics background to problem-solve • Think laterally, including outside the nuclear medicine context • Research a problem and postulate a solution, keeping in mind the boundaries of your understanding and ability • Enlist the help of others with relevant skills
	Module 4 – Professional Development and Management
	Sub-module 4.3: Quality Management
Objective	To provide the resident with understanding of the organisation and implementation of a comprehensive system for quality management
Prerequisite	Module 4.1: Professional awareness
Competencies Addressed	Understanding of the structure of a quality system. Ability to implement and maintain the physics aspects of the quality system.

Core Knowledge	(1) Basic knowledge of quality management standards. (2) Understanding of the terms used such as: quality assurance, quality control, quality audit, risk management, human resources management. (3) Knowledge of the national regulations. (4) Understanding of all elements needed in a quality system. (5) Basic knowledge of how a quality system is adapted to the nuclear medicine practice. (6) Basic knowledge of the maintenance of a quality system.
Recommended Elements of Training	• Study a suitable standard on quality management. • Explain the meaning of relevant terms such as: quality assurance, quality control, quality audit, risk management, human resources management, and traceability. • Describe the role of all professionals in the quality system. • Review which parts of the standard that has been implemented in the nuclear medicine department. • Give recommendations on how the quality system for the nuclear medicine department could be improved. • Describe the role of the medical physicist in the Quality system. • Check if the existing quality documents are properly updated • Check if the existing quality documents are used in clinical practice. • Study an entire patient procedure and describe how different parts of the quality system influences the quality of the procedure. **Describe which role the quality system plays during the "life cycle" of a nuclear medicine equipment.**
Knowledge Sources	[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Management Audits in Nuclear Medicine Practices IAEA, Vienna (2008). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1371_web.pdf. [2] INTERNATIONAL ELECTROTECHNICAL COMMISSION, General requirements for the competence of testing and calibration laboratories, IEC-17025: 2005, IEC, Geneva (2005). [3] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, ISO 9000 / ISO 14000 Quality management principles. ISO, http://www.iso.org/iso/iso_catalogue/management_standards/iso_9000_iso_14000/qmp.htm. [4] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Quality Management systems – requirements. ISO, (2008), http://www.iso.org/iso/iso_catalogue/management_standards.htm. [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection in Nuclear Medicine Part 9 Quality Assurance, http://rpop.iaea.org/RPOP/RPoP/Content/Documents/TrainingNuclearMedicine/Lectures/RPNM_Part09_qa_WEB.ppt#1

	Module 4 – Professional Development and Management
	Sub-module 4.4: Clinical Audit
Objective	To demonstrate an understanding of the purpose, conduct and analysis of a clinical audit.
Prerequisite	
Competencies Addressed	An understanding of nature, purpose and importance of clinical audit in the nuclear medicine setting. The ability to effectively contribute as a member of a multidisciplinary team to a nuclear medicine clinical audit.
Core Knowledge	• The purpose of clinical audit in nuclear medicine. • The role of the physicist in clinical audit. • Familiarity with local legislative requirements for clinical audits.
Recommended Elements of Training	• Acquire an understanding of the purpose of clinical audit and what it involves from the provided knowledge sources. • Become familiar with any local legislative requirements for clinical audit. • Identify practical examples of clinical audit in Nuclear Medicine. • Consult relevant audit documents and other sources to ascertain the acceptable standards for medical physics in a nuclear medicine department. • Demonstrate ability to assemble departmental information on medical physics activities in a department (e.g. QA and calibration documentation) prior to the commencement of an audit visit. • Demonstrate practical aspects of medical physics activities in a department (e.g. in QA and calibration) at the request of an audit team member during an audit visit. • Respond to suggestions to change of work practice as a result of an audit visit.
Knowledge Sources	[1] Proceedings of International Symposium on Practical Implementation of Clinical Audit for Exposure to Radiation in Medical Practices, Tampere, Finland, 24th -27th May, (2003), http://www.clinicalaudit.net/fi_etusivu.html. [2] COMMISSION OF THE EUROPEAN COMMUNITIES, European Commission Guideline on Clinical Audit for Medical Radiological Practices (Diagnostic Radiology, Nuclear Medicine and Radiotherapy), European Commission, Luxembourg (2009). http://ec.europa.eu/energy/nuclear/radiation_protection/publications_en.htm.

[3] FULLBROOK, A., WRIGHT, L., HALLAND, J., MORTON, R., Clinical Audit: Useful or a waste of time?, Nuclear Medicine Communications **26** 3 (2005) 294-295.
[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Management Audits in Nuclear Medicine Practices IAEA, Vienna (2008). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1371_web.pdf.
[5] OFFICE OF EDUCATION AND TRAINING MEDICAL COUNCIL OF IRELAND, Criteria for Clinical Audit, (2004).
[6] PETERS, A.M., et al., Clinical audit in nuclear medicine, Nucl Med Commun **25** 2 (2004) 97-103.

	MODULE 5 - EQUIPMENT PROCUREMENT, ACCEPTANCE TESTING AND COMMISSIONING
Objective	To acquaint the resident with procedures for acquiring new equipment, acceptance, reference testing and commissioning.
Expected Duration	10% of the entire time
Sub-Modules	5.1 Acquisition and life cycle of nuclear medicine equipment 5.2 Dose calibrator acceptance testing 5.3 Scintillation probe and well counter acceptance testing 5.4 Gamma camera, SPECT and CT acceptance test and commissioning 5.5 PET and CT acceptance test and commissioning
Core Reading	[1] GRAY, J.E., MORIN, R.L., Purchasing medical imaging equipment, Radiology 171 1 (1989) 9-16. [2] EARLY, P.J., SODEE, D.B., Principles and Practice of Nuclear Medicine, 2nd edn, Mosby (1994). [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Medicine Resources Manual, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1198_web.pdf.
	Module 5 - Equipment Procurement, Acceptance Testing and Commissioning
	Sub-module 5.1: –Acquisition and Life Cycle of Nuclear Medicine Equipment
Objective	To develop the competency necessary to prepare specifications for new equipment and to assist in the management of nuclear medicine equipment.
Prerequisite	Sub-module 2.5 Areas Designated for the Use of Unsealed Radioactive Material Sub-module 2.6 Radiation Protection Considerations in Design of New Facilities
Competencies Addressed	To understand the procedures for acceptance testing and equipment maintenance as well as verification of equipment performance after maintenance. The capability to make budgetary requests, prepare the specifications and acquire suitable equipment through a tendering process

Core Knowledge	• Knowledge of issues relevant to equipment selection (e.g. Equipment technology, functionality, performance, compatibility, training, maintenance service, building and building services, delivery and installation, and local purchasing procedures). • Familiarity with current products, key differences in available technologies. • Prepare a project and budget proposal • Principles of Equipment Planning (a) Creation of the business plan (b) Clinical consideration (c) Technical considerations including power supply and earthing/grounding (d) Maintenance planning (e) Equipment limitations (f) Workflow and limitations (g) Room layout (h) Workload and radiation shielding • Principles of Equipment Acquisition (a) Specification (b) Tender (c) Selection of vendors • Principles of Equipment Installation, Acceptance Testing and Commissioning (a) The need for oversight of the installation process (b) The role of acceptance testing (c) The role of commissioning • Principles of equipment oversight (a) Quality control programmes (b) Equipment service and maintenance • Principles of Equipment Disposal • Concept of equipment life cycle
Recommended Elements of Training	• Demonstrate an understanding of the process involved in equipment requisition and acquisition • Review and report on department needs on: o Equipment technology o Functionality o Performance o Compatibility o Training o Maintenance service o Building and building services o Delivery and installation • Perform: o Market research on equipment technology o Technology assessment

	○ Review of procurement documentation • Submit project proposal and budgetary request • Prepare/perform within a multidisciplinary team ○ Tender specification ○ Tender evaluation ○ Tender recommendation • Equipment business plan and draft of a tender document • Equipment Planning ○ Development of room layout ○ Establish workload and radiation shielding requirements • Equipment Acquisition ○ Development of specifications based on needs analysis ○ Selection of primary vendors ○ Selection of final vendor ○ Negotiation with vendors to optimize equipment and price • Supervise and mentor technical staff to successfully complete a project on schedule. • Attend a course on ○ Time management ○ Conflict resolution ○ Performance management • Oversight of equipment maintenance • Supervise the maintenance of nuclear medicine equipment, such as: ○ Participate in trouble-shooting equipment faults for a period of time. ○ Assume responsibility for different items of equipment for a period of time, including being a contact point for equipment faults and liaising with engineers. ○ Write a report and/or present to the physics department case studies outlining the equipment fault, its cause and required verification measurements required to ensure accurate dose delivery. • Understand differences between units from different manufacturers. • Perform appropriate testing after maintenance, calibration, and software upgrades to assure image quality and patient safety • Principles of Equipment Disposal ○ Assist in planning for equipment replacement and disposal ○ Negotiate for beneficial arrangements for equipment removal • Ensure appropriate disposal considering hazardous materials in the equipment
Knowledge Sources	[1] GRAY, J.E., MORIN, R.L., Purchasing medical imaging equipment, Radiology 171 1 (1989) 9-16. [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for Radioactivity Measurement in Nuclear Medicine, Technical Reports Series No. 454, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/TRS454_web.pdf.

	Module 5 - Equipment Procurement, Acceptance Testing and Commissioning
	Sub-module 5.2 - Dose Calibrator Acceptance Testing
Objective	Become familiar with the procedure for acceptance testing of a new dose calibrator.
Prerequisite	Sub-module 5.1 Acquisition and life cycle of Nuclear Medicine Equipment Familiarity with basic principles of dose calibrator functions and operation Familiarity with hot lab procedures and radiation safety measures required to handle the sources associated with the experimental work.
Competencies Addressed	An understanding of the procedure for initial acceptance of a dose calibrator Ability to perform dose calibrator acceptance testing

Core Knowledge	• Principles of operation of the dose calibrator
	• Factors affecting dose calibrator accuracy
	  o Background activity
	  o Source geometry
	  o Source position
	  o Sample activity
	  o Isotope measured
	• Use of certified radioactive sources
	• 'Precision' and 'accuracy'
	• Criteria for acceptable performance
	• Appropriate action if equipment fails acceptance testing
	• Understand the reference test as part of the QC

Recommended Elements of Training	Perform the following tests on a dose calibrator: • Physical Inspection • Precision and Accuracy • Linearity of Activity Response • Background test • Dose calibrator geometry test
Knowledge Sources	[1] EARLY, P.J., SODEE, D.B., Principles and Practice of Nuclear Medicine, 2nd edn, Mosby (1994). [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for Radioactivity Measurement in Nuclear Medicine, Technical Reports Series No. 454, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/TRS454_web.pdf. [3] VALLEY, J.F., BULLING, S., LERESCHE, M., WASTIEL, C., Determination of the efficiency of commercially available dose calibrators for beta-emitters, J Nucl Med Technol 31 1 (2003) 27-32. [4] Manual for dose calibrator

Notes	This module requires handling of a large amount of activity. Make sure that proper radiation safety procedures are followed to minimise dose to yourself and other staff members. It may be useful for you to wear a personal electronic dosimeter to get an immediate reading of the dose received.
	Module 5 - Equipment Procurement, Acceptance Testing and Commissioning
	Sub-module 5.3 – Scintillation probe and Well Counter Acceptance Testing
Objective	Become familiar with the procedure for acceptance testing of a new scintillation probe or well counter.
Prerequisite	Familiarity with basic principles of scintillation probe or well counter functions and operation. Familiarity with hot lab procedures and radiation safety measures required to handle the sources associated with the experimental work.
Competencies Addressed	An understanding of the procedure for initial acceptance testing of a scintillation probe or well counter. Ability to perform acceptance testing of a scintillation probe or well counter.

Core Knowledge	• Components and principles of operation of the
	  o scintillation probe system
	  o well counter
	• Chi squared test
	• Recommended acceptance tests
	• Understand the reference test as part of the QC.

Recommended Elements of Training	Perform the following tests on the scintillation probe and well counter systems as the acceptance test and the annual basis as the reference test: • Physical inspection • Test of function of scaler - timer/rate meter • Test of energy calibration • Test of energy resolution (% FWHM) • Test of sensitivity • Test of counting precision (Chi squared test) • Test of linearity of energy response • Test of integral background count rate • Test of linearity of activity response • Test of preset analyser settings.

Knowledge Sources	[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Medicine Resources Manual, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1198_web.pdf. [2] KNOLL, G.F., Radiation Detection and Measurement, 3rd edn, John Wiley & Sons, New York (1999). [3] Manual for scintillation probe and well counter.
	Module 5 - Equipment Procurement, Acceptance Test and Commissioning
	Sub-module 5.4 - Gamma Camera/SPECT and CT Acceptance Testing and Commissioning
Objective	Be able to demonstrate familiarity with the processes involved in acceptance testing of gamma cameras/SPECT and CT.
Prerequisite	Familiarity with all aspects of gamma camera/SPECT and CT design and performance, both hardware and software Familiarity with hot lab procedures and radiation safety requirements for handling the sources required for the acceptance tests
Competencies Addressed	An understanding of the procedure for acceptance test of the gamma camera/SPECT and CT systems Ability to perform acceptance testing of the gamma camera / SPECT systems.
Core Knowledge	• Standards for gamma camera/SPECT acceptance testing • Manufacturer specifications of system performance • Interpretation of acceptance test results • Criteria for acceptable performance • Appropriate action if equipment fails acceptance testing • Basic understanding of CT acceptance test. • Understand the reference test as part of the QC
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency. • Design a set of acceptance tests to be performed on a gamma camera system following its commissioning which determine whether the camera meets required performance specifications. • Perform acceptance testing on a SPECT system o Mechanical inspection o Pixel size o Centre Of Rotation (COR) o Tomographic uniformity o Tomographic resolution (air) o Tomographic resolution (scatter)

	o Slice thickness o Rotational sensitivity uniformity o Total performance study • Produce a report which shows the results of the acceptance tests, flagging any non compliances (based on your original minimum performance specifications) and indicating whether the system should be accepted for routine clinical imaging. • Obtain the relevant specifications from the vendors of currently available gamma cameras, SPECT and compare them to the specification document. • Prepare a document detailing acceptance tests to be performed on a gamma camera system capable of SPECT. • Write a report detailing the results of the acceptance tests. Flag any non compliances (based on your criteria from the previous step) and indicate whether the system should be accepted for routine clinical imaging. • Discuss whether the camera meets any local national standards for gamma camera performance (if available). • Perform the reference test at the annual basis. Compare the results to the acceptance test to see any changes or deteriorations. • Observe the acceptance test of CT.
Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Rotating Scintillation Camera SPECT Acceptance Testing and Quality Control, AAPM Rep. 22, New York (1987). http://www.aapm.org/pubs/reports/rpt_22.PDF. [2] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Quantitation of SPECT Performance, Report of AAPM Nuclear Medicine Committee Task Group 4, AAPM Rep. 52, New York (1995). http://www.aapm.org/pubs/reports/rpt_52.PDF. [3] BABICHEVA, R., BENNIE, N., COLLINS, L., GRUENEWALD, S., Parallel hole collimator acceptance tests for SPECT and planar studies, Australas Phys Eng Sci Med 20 4 (1997) 242-7. [4] BLOKLAND, J.A., CAMPS, J.A., PAUWELS, E.K., Aspects of performance assessment of whole body imaging systems, Eur J Nucl Med 24 10 (1997) 1273-83. [5] MURPHY, P.H., Acceptance testing and quality control of gamma cameras, including SPECT, J Nucl Med 28 7 (1987) 1221-7. [6] NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, NEMA Standards Publication NU 1-2001, Performance Measurements of Scintillation Cameras (2001). [7] Gamma camera vendor brochures and specification sheets.

	Module 5 - Equipment Procurement, Acceptance Testing and Commissioning
	Sub-module 5.5 – PET and CT Acceptance Testing and Commissioning
Objective	Be able to demonstrate familiarity with the processes involved in acceptance testing of PET/CT.
Prerequisite	Familiarity with basic principle of the PET /CT function and operation
Competencies Addressed	An understanding of NEMA procedures for PET acceptance testing Ability to perform (a) PET acceptance testing and commissioning (b) SUV calibration and check SUV calibration accuracy
Core Knowledge	• Standards for PET system acceptance testing such as NEMA NU 2-2007. • Manufacturer specifications of system performance • Interpretation of acceptance test results • Criteria for acceptable performance • Appropriate action if equipment fails acceptance testing • Basic understanding of CT acceptance test.

Recommended Elements of Training	• Prepare a report comparing the various technologies used for PET coincidence imaging for whole body PET studies.
	  • The comparison should include the following technologies:
	  o Gamma camera based coincidence system
	  o GSO, LySO PET systems (e.g. Philips Gemini)
	  o BGO based systems (e.g. GE Discovery Series)
	  o LSO (e.g. Siemens Biograph,)
	  o PET scanners vs. PET/CT hybrid scanners
	• Perform PET acceptance test according to the NEMA Nu-2 2007
	  • The following aspects of performance should be covered
	  o Count rate performance
	  o Spatial Resolution
	  o Corrections applied and quantitative accuracy
	  o 3D vs. 2D acquisitions in terms of sensitivity, injected activity and effect of activity outside field of view.
	  o Relative merits of CT vs. non-CT based attenuation correction
	  o Appropriate NEMA standard to evaluate performance for whole body studies (NEMA 2001)
	  o Activity injected into patient and uptake period
	  o Throughput of studies and relative cost of systems
	  • Observe the acceptance test of CT.

	• The SUV is a quantitative index and hence requires activity concentration in the patient to be estimated in absolute terms with the PET scan. o Describe each of the corrections and calibrations which have to be performed to achieve quantitative values o How does this impact on the routine QC of the PET scanner o Design and describe an experiment to verify that the PET scanner provides accurate activity concentration values and all corrections and calibrations are appropriately applied.
Knowledge Sources	[1] FAHEY, F.H., Data acquisition in PET imaging, J Nucl Med Technol 30 2 (2002) 39-49. [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for PET and PET/CT Systems, Human Health Series No. 1, IAEA, Vienna (2009). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1393_web.pdf. [3] NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, NEMA Standards Publication NU-2-2007 Performance Measurements of Positron Emission Tomographs (2007). [4] VALK, P.E., BAILEY, D.L., TOWNSEND, D.W., MAISEY, M.N., Positron Emission Tomography. Basic Science and Clinical Practice, Springer (2003). [5] ImPACT website (www.impactscan.org)

	MODULE 6 - RADIOACTIVITY MEASUREMENTS AND INTERNAL DOSIMETRY
Objective	To provide the resident with clinical knowledge and skills to measure radioactivity and perform internal dosimetry calculations.
Expected Duration	10% of overall time
Sub-Modules	6.1 Use of traceable standards for radioactivity measurements 6.2 Formalism and application of internal dosimetry 6.3 Absorbed dose from diagnostic nuclear medicine radiopharmaceuticals 6.4 Quantitative nuclear medicine imaging 6.5 Patient-specific dosimetry
Core Reading	[1] CHERRY, S.R., SORENSON, J.A., PHELPS, M.E., Physics in Nuclear Medicine, 3rd edn, WB Saunders, Philadelphia (2003). [2] KNOLL, G.F., Radiation Detection and Measurement, 3rd edn, John Wiley & Sons, New York (1999). [3] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Absorbed-dose specification in Nuclear Medicine, ICRU Rep. 67, Bethesda, MD (2002). [4] MIRD pamphlets http://interactive.snm.org/index.cfm?PageID=2199&RPID=969 [5] SJOGREEN, K., LJUNGBERG, M., WINGARDH, K., MINARIK, D., STRAND, S.E., The LundADose Method for Planar Image Activity Quantification and Absorbed-Dose Assessment in Radionuclide Therapy, Cancer Biother Radiopharm **20** 1 (2005) 92-97.
	Module 6 - Radioactivity Measurements and Internal Dosimetry
	Sub-module 6.1: Use of Traceable Standards for Radioactivity Measurements
Objective	To acquire the knowledge and skills to be able to perform and understand quality assurance principles for radioactivity measurement in nuclear medicine.
Prerequisite	Sub-module 7.2: QC for Dose calibrator Sub-module 7.3: QC for Scintillation probe and well counter
Competencies Addressed	An understanding of the traceability chain for radionuclide activity measurements in the nuclear medicine setting. The ability to apply quality assurance principles and estimate the uncertainties involved in radioactivity measurements in the clinical setting.
Core	• Traceability to primary standards.

Knowledge	• Uncertainties involved when measuring the clinical vials c.f. the standard source(s). • Methods for cross-calibrations. • Intercomparisons.
Recommended Elements of Training	• Perform decay corrections to reference time. • Investigate the volume dependence for activity meter measurements. • Review established constancy tests for activity meters by repeat measurements of the check source and record the decay-corrected results on a constancy graph. Note any deviations or trends. • Prepare an uncertainty analysis for measuring the radionuclide activity used in the clinic. • Perform cross-calibrations with instruments available in the clinic, e.g. gamma-well counters, gamma probes, solid-state detectors. Discuss the uncertainties in each measurement. • Participate in intercomparison of standard sources with other institutes. • Review or set up an appropriate quality assurance program for radioactivity measurements.
Knowledge Sources	[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for Radioactivity Measurement in Nuclear Medicine, Technical Reports Series No. 454, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/TRS454_web.pdf. [2] KNOLL, G.F., Radiation Detection and Measurement, 3rd edn, John Wiley & Sons, New York (1999). [3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values, ICRP Publication 89, Vol 32 No 3-4, Pergamon Press, Oxford and New York (2002). [4] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Nuclear Decay Data for Dosimetric Calculations Rep. 107, Ann. ICRP 38(3) (2008).
	Module 6 - Radioactivity Measurements and Internal Dosimetry
	Sub-module 6.2: Formalism and Application of Internal Dosimetry
Objective	To acquire the knowledge and skills of applying established formalisms for internal dosimetry calculations.
Prerequisite	Sub-module 1.2: Basic principles of radiation biology and epidemiology
Competencies addressed	An understanding of the formalism established for internal dose calculations, including its limitations. Ability to calculate absorbed dose to organs according to the MIRD formalism as well as to derive the effective dose.

Core Knowledge	• Identifying the physical and biological parameters for absorbed dose calculation. • Choosing the proper methods of data collection. • Identifying the factors affecting the absorbed dose to particular organs. • Understanding biokinetic analysis and modelling and the fundamentals of compartment analysis. • Understanding the MIRD formalism so that calculation of absorbed and effective dose can be made for different clinical investigations. • Understanding the uncertainties involved in the various steps. • Estimating the absorbed dose to foetus. • Fundamental understanding of cellular dosimetry (optional).
Recommended Elements of Training	• Review the definitions of absorbed dose, equivalent dose and effective dose. • Choose various nuclear medicine procedures, including paediatric procedures. Describe the measurements required to calculate organ cumulative activity for this procedure. Describe how these measurements could be performed using equipment available in your department. Describe the uncertainties involved. • Using measured or published biokinetic data, calculate the cumulative activity for the important source organs, in the chosen procedure. Compare the results with the dose information provided by the distributing company for that radiopharmaceutical. • Search the literature for examples of papers where individual dosimetry has been done. Note the methods for data acquisition. • Evaluate how clinical examinations with a scintillation camera can be designed in order to constitute the basis for an absorbed dose estimate. What data and how many measurements are needed? What other sources can be useful to support the acquired data? • Study the available literature on estimates of foetal dose from different radiopharmaceuticals, based on standardized kinetic models. Specifically investigate the case of a foetal thyroid dose after the radioiodine (I-131) administration to a woman in a different period of gestation. Search also the literature to explore how the above dose assessment changes in hyperthyroid or athyroid patients.
Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Radiolabelled Antibody Tumor Dosimetry (Reprinted from Medical Physics, Vol. 20, Issue 2), AAPM Rep. 40, New York (1993). http://www.aapm.org/pubs/reports/RPT_40.pdf. [2] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, A Primer for Radioimmunotherapy and Radionuclide Therapy, AAPM Rep. 71, New York (2001). http://www.aapm.org/pubs/reports/RPT_71.pdf. [3] CHERRY, S.R., SORENSON, J.A., PHELPS, M.E., Physics in Nuclear Medicine, 3rd edn, WB Saunders, Philadelphia (2003).

	[4] LOEVINGER, R., BUDINGER, T.F., WATSON, E.E., MIRD Primer for Absorbed Dose Calculations, Revised, The Society of Nuclear Medicine (1991). [5] SGOUROS, G., Dosimetry of internal emitters, J Nucl Med **46 Suppl 1** (2005) 18S-27S. [6] STABIN, M.G., Radiation Protection and Dosimetry: An Introduction to Health Physics, Springer (2007). [7] STABIN, M.G., BRILL, A.B., State of the art in nuclear medicine dose assessment, Semin Nucl Med **38** 5 (2008) 308-20. [8] RUSSELL, J.R., STABIN, M.G., SPARKS, R.B., WATSON, E.E., Radiation Absorbed Dose to the Embryo/Foetus from Radiopharmaceuticals, Health Physics **73** 3 (1997) 756-769. [9] STABIN, M.G., WATSON, E.E., MARCUS, C.S., SALK, R.D., Radiation dosimetry for the adult female and foetus from iodine-131 administration in hyperthyroidism, J Nucl Med **32** (1991) 808-813.
	Module 6 - Radioactivity Measurements and Internal Dosimetry
	Sub-module 6.3: Radiation dose from Diagnostic Nuclear Medicine Radiopharmaceuticals
Objective	To acquire the knowledge and skills to use look-up tables for estimating absorbed and effective dose from diagnostic nuclear medicine procedures
Prerequisite	Sub-module 6.2: Formalism and application of internal dosimetry
Competencies Addressed	An understanding of the underlying methods for the derived tables available for internal dose estimations, including the uncertainties expected for different patients. The ability to use established tables for estimating absorbed dose and effective dose to the patient.
Core Knowledge	(1) Quantities and units • Understand the concepts of absorbed dose, equivalent dose and effective dose listed in ICRU60, ICRP60 and ICRP103. • Understand the appropriate applications of the different quantities (e.g. equivalent dose for whole organs, effective dose only for low-dose stochastic effects). (2) Dose estimates • Importance of appropriate biokinetic data in determining internal dose. • Variations in biokinetic data with age, gender and physiology/pathology, and appreciate how this affects internal dose • Reliable sources of generic radiopharmaceutical dosimetry data.

Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency • Estimate the effective absorbed dose, and the equivalent dose to specific organs and tissues, for three of the procedures commonly used in the practice or institution where the resident works. • For one of the procedures, comment on - changes in absorbed dose with the weight and age of the patient. - the dose to the embryo/foetus in pregnant patients as a function of stage of gestation. - the effect of non-standard physiology such as impaired renal clearance on the absorbed doses received - the estimated doses with reference dose levels and the doses given in the "package insert" for the radiopharmaceutical used. • Prepare a basic dosimetry report for the chosen procedure
Reading List	[1] MEDICAL INTERNAL RADIATION DOSE (MIRD) pamphlets, http://interactive.snm.org/index.cfm?PageID=2199&RPID=9691. [2] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Radiation Dose to Patients from Radiopharmaceuticals, Vol 18 nos. 1- 4, ICRP Publication 53, Pergamon Press, Oxford and New York (1988). [3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Radiation dose to patients from radiopharmaceuticals, ICRP publication 80 (Addendum 2 to ICRP Publication 53), Pergamon Press, Oxford and New York (1998). [4] LOEVINGER, R., BUDINGER, T.F., WATSON, E.E., MIRD Primer for Absorbed Dose Calculations, Revised, The Society of Nuclear Medicine (1991). [5] RADIATION INTERNAL DOSE INFORMATION CENTRE (RIDIC), various compendium, www.orau.gov//ehsd/doses.htm.
	Module 6 - Radioactivity Measurements and Internal Dosimetry
	Sub-module 6.4: Quantitative Nuclear Medicine Imaging
Objective	To acquire the knowledge and skills to be able to derive quantitative information from nuclear medicine images.
Prerequisite	Sub-modules 5.2, 5.3, 5.4, 7.1, 7.4, (Dose calibrator, Scintillation probe and well counter, Gamma camera and SPECT, Operation of a clinical acquisition and processing/reviewing workstation, Computer image processing techniques)
Competencies Addressed	An understanding of the main factors affecting quantitative measurements in nuclear medicine Ability to acquire quantitative measures from planar, SPECT and PET studies

Core Knowledge	• Fundamentals of image analysis • Patient, physical and technical factors affecting accurate activity quantification: anatomic, physiological, time dependent, instrumentation and image processing factors. • Estimation of activity from planar images. • Common approaches for quantitative SPECT studies. • SPECT quantification and activity/cross calibration factor
Recommended Elements of Training	(1) Validation of methods for activity estimation from planar images. The work could include • Review of methods given in the literature and selection of appropriate method • Validation of the method using a phantom which simulates activity in the lungs and in the liver, including simulation of the lower density of the lungs. (2) Perform SPECT activity quantification calibration and evaluation • Review methods for SPECT activity quantification and select method which can be implemented with the equipment you have in the department. • With a uniform phantom, calibrate the SPECT system to provide a calibration factor which can convert SPECT counts per voxel to activity per mL (e.g. kBq/mL). • With a uniform phantom which is different from the calibration phantom and which contains a known activity concentration, validate the method you have devised for absolute activity estimation with SPECT. (3) Investigate the effect of acquisition parameters (e.g. time per projection, matrix size, number of projections on the activity calibration factor). (4) Design and carry out a phantom experiment which demonstrates the effect of partial volume on activity quantification (can be demonstrated either for planar or SPECT studies).
Knowledge Sources	[1] MIRD Pamphlet No. 16: Techniques for quantitative radiopharmaceutical biodistribution data acquisition and analysis for use in human radiation dose estimates, J Nucl Med **40** (1999) 37S-61S. [2] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Rotating Scintillation Camera SPECT Acceptance Testing and Quality Control, AAPM Rep. 22, New York (1987). http://www.aapm.org/pubs/reports/rpt_22.PDF. [3] BARNES, W.E., "In vivo quantitation of activity by planar imaging", Nuclear Medicine, (HENKIN, R.E., et al., Eds), Mosby-Elsevier, Philadelphia, PA, (2006). [4] PARKER, J.A., Quantitative SPECT: basic theoretical considerations, Sem Nucl Med **19** (1989) 3-12. [5] ROSENTHAL, M.S., et al., Quantitative SPECT imaging: a review and recommendations by the Focus Committee of the Society of Nuclear Medicine Computer and Instrumentation Council, J Nucl Med **36** 8 (1995) 1489-513.

	Module 6 - Radioactivity Measurements and Internal Dosimetry
	Sub-module 6.5 – Patient-Specific Dosimetry
Objective	To acquire the knowledge and skills to understand when patient-specific dosimetry is required and how to perform it.
Prerequisites	Sub-modules 6.2, 6.4. (Formalism and application of internal dosimetry, Quantitative nuclear medicine imaging)
Competencies Addressed	An understanding of the tools and requirements needed for performing patient-specific internal dosimetry. The ability to calculate patient-specific dosimetry from repeat images and uptake measurements.
Core Knowledge	• Situations when there is a need for patient-specific dosimetry • Tools available for individual dosimetry • Uncertainties involved and methods available to reduce them (tracer studies, repeat imaging, sampling etc.) • Process by which research proposals are evaluated and approved • Comparison of the absorbed dose from novel and established diagnostic procedures to dose constraints for exposures for research purposes • Realize how to suggest recommendations on referral to the regulatory authority or review by independent medical physicist as appropriate.
Recommended Elements of Training	• Practise to advice on and perform internal dosimetry for therapeutic procedures • Explain to a research applicant the dose constraints and other recommendations in e.g. the national Code of Practice on Exposure of Humans to Ionizing Radiation for Research Purposes (ARPANSA, 2004/2005) • Independently verify and document an estimate of radiation dose to a subject, in a research study from established diagnostic radiopharmaceutical procedures including dual modality imaging • other radiological imaging procedures in the study (preferably by consulting the MP specialized in diagnostic radiology) • novel diagnostic or therapy radiopharmaceutical procedures • Prepare dosimetry reports for pregnant patients • Read one of the publications on patient-specific dosimetry from the suggested reading list and prepare a short summary of the methodology utilised to estimate the absorbed dose
Knowledge Sources	[1] MEDICAL INTERNAL RADIATION DOSE (MIRD) pamphlets, http://interactive.snm.org/index.cfm?PageID=2199&RPID=9691. [2] DEWARAJA, Y.K., et al., Accurate dosimetry in 131I radionuclide therapy using patient-specific, 3-dimensional methods for SPECT reconstruction and absorbed dose calculation, J Nucl Med **46** 5 (2005) 840-9. [3] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Absorbed-dose specification in Nuclear Medicine, ICRU Rep. 67, Bethesda, MD (2002).

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[5] SGOUROS, G., et al., Patient-specific, 3-dimensional dosimetry in non-Hodgkin's lymphoma patients treated with 131I-anti-B1 antibody: assessment of tumor dose-response, J Nucl Med **44** 2 (2003) 260-8.
[6] YORIYAZ, H., STABIN, M.G., DOS SANTOS, A., Monte Carlo MCNP-4B-based absorbed dose distribution estimates for patient-specific dosimetry, J Nucl Med **42** 4 (2001) 662-9.
[7] http://www.arpanse.gov.au/pubs/rps/rps/rps8.pdf

	MODULE 7 – QUALITY CONTROL OF NUCLEAR MEDICINE EQUIPMENT
Objective	To acquaint the resident with procedures for the Quality control of nuclear medicine equipment
Expected Duration	15% of total time
Sub-Modules	7.1 Design and supervision of a routine QC program 7.2 Dose calibrator 7.3 Scintillation probe and well counter 7.4 Gamma camera and SPECT 7.5 PET 7.6 Display and Hardcopy Devices 7.7 BMD
Core Reading	[1] AMERICAN COLLEGE RADIOLOGY, ACR technical standard for medical nuclear physics performance monitoring of gamma cameras, (2008). [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for PET and PET/CT Systems, Human Health Series No. 1, IAEA, Vienna (2009). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1393_web.pdf. [3] ZANZONICO, P., Routine quality control of clinical nuclear medicine instrumentation: a brief review, J Nucl Med **49** 7 (2008) 1114-31. [4] AUSTRALIAN AND NEW ZEALAND SOCIETY OF NUCLEAR MEDICINE, Minimum quality control requirements for nuclear medicine equipment, Technical Standards Committee Place, Published.(1999) http://www.munatha.com.au/ANZAPNM/NM-QualityControl.pdf. [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Control Atlas for Scintillation Camera Systems, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1141_web.pdf. [6] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Medicine Resources Manual, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1198_web.pdf. [7] NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, NEMA Standards Publication NU 1-2001, Performance Measurements of Scintillation Cameras (2001). [8] NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, NEMA Standards Publication NU-2-2007 Performance Measurements of Positron Emission Tomographs (2007).

	Module 7 – Quality Control of Nuclear Medicine Equipment
	Sub-module 7.1 – Design and Supervision of a Routine QC Program
Objective	To understand and manage all aspects of a routine nuclear medicine quality control programme
Prerequisite	Module 4.2: Communication
Competencies Addressed	An understanding of the methods for the clinical implementation and supervision of a quality control programme The ability to manage a QC programme including the appropriate use of instrumentation, test selection and test frequency
Core Knowledge	• Principles of quality control • Regulatory requirements o Roles and responsibilities of staff involved in the QC programme o Which staff groups are required to perform different types of test o Supervision requirements o Training needs and delivery o Reporting and record keeping • Quality Control tests o Types of test o Complexity of differing tests o Applicability of tests o Appropriate frequencies for performance of different tests o Use of control charts including operating levels, upper and lower control limits
Recommended Elements of Training	• Participation in the training of staff to perform QC tests • Establishment of o operating levels, o control limits o control charts o record keeping • Implement QC program to include o Dose calibrator o Scintillation probe and well counter o Gamma camera o SPECT camera o PET scanner o CT scanner o BMD o appropriate quality control charts

	• Carry out periodic review of quality control program with other staff o Perform medical physicist level quality control tests o Develop quality control program o Monitor technologist's quality control tests
Knowledge Sources	[1] AMERICAN COLLEGE RADIOLOGY, Nuclear medicine guidelines, Place, Published http://www.acr.org/s_acr/sec.asp?CID=1074&DID=14838. [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for PET and PET/CT Systems, Human Health Series No. 1, IAEA, Vienna (2009). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1393_web.pdf. [3] ZANZONICO, P., Routine quality control of clinical nuclear medicine instrumentation: a brief review, J Nucl Med **49** 7 (2008) 1114-31. [4] CHERRY, S.R., SORENSON, J.A., PHELPS, M.E., Physics in Nuclear Medicine, 3rd edn, WB Saunders, Philadelphia (2003). [5] CHRISTIAN, P., WATERSTRAM-RICH, K., Nuclear Medicine and PET/CT Technology and Technique, 6th edn, Mosby, St. Louis (2007). [6] CLASSE, J.M., et al., Prospective comparison of 3 gamma-probes for sentinel lymph node detection in 200 breast cancer patients, J Nucl Med **46** 3 (2005) 395-9. [7] GRANTHAM, V., Nuclear Medicine Instrumentation and Quality Control: A Review, in eradimaging, Place, Published.(2007) http://www.eradimaging.com/site/article.cfm?ID=88. [8] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for Radioactivity Measurement in Nuclear Medicine, Technical Reports Series No. 454, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/TRS454_web.pdf. [9] NICHOLS, K.J., et al., Instrumentation quality assurance and performance, J Nucl Cardiol **13** 6 (2006) e25-41. [10] SOCIETY OF NUCLEAR MEDICINE, Performance and responsibility guidelines for NMT: revision 2003. Society of Nuclear Medicine Procedure Guidelines Manual. , Place, Published.(2003) http://interactive.snm.org/docs/pg_ch16_0803.pdf. [11] STEVES, A.M., WELLS, P.C., Review of Nuclear Medicine Technology: Preparation for Certification Examinations, 3rd edn, Society of Nuclear Medicine, Reston, VA (2004). http://interactive.snm.org/index.cfm?PageID=3423. [12] THE INTERSOCIETAL COMMISSION FOR THE ACCREDITATION OF NUCLEAR MEDICINE LABORATORIES, Standards for nuclear cardiology, nuclear medicine and PET accreditation http://www.icanl.org/icanl/pdfs/2008ICANLStandards.pdf. [13] UNITED STATES NUCLEAR REGULATORY COMMISSION, Regulatory guide 10.8 - guide for the preparation of applications for medical use programs, (1987). http://www.nrc.gov/reading-rm/doc-collections/reg-guides/general/active/10-008/index.html.

	[14] VOTAW, J.R., The AAPM/RSNA physics tutorial for residents. Physics of PET, Radiographics **15** 5 (1995) 1179-90.
	Module 7 – Quality Control of Nuclear Medicine Equipment
	Sub-module 7.2 – QC of a Dose Calibrator
Objective	To be competent in all dose calibrator quality control procedures needed to ensure accurate measurements of radioactivity
Prerequisite	Sub-module 5.2: Dose calibrator acceptance testing
Competencies Addressed	An understanding of the effect of geometry, energy and type of emissions on radioactivity measurements. The ability to perform basic dose calibrator QC including constancy, background, linearity and accuracy checks and set appropriate action levels.
Core Knowledge	• The meaning of the terms linearity of response, constancy, accuracy, geometry dependence. • How to perform the following QC checks o Physical inspection o High voltage visual inspection check o Zero check and adjustment o Background check o Constancy o Geometry dependence o Precision and accuracy o Linearity of activity response • Limits of acceptability • Setting action levels • Recommended frequency of checks • Importance of record keeping • Creating a control chart
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency • Critically review a department's dose calibrator QC procedures and action levels. • Perform a background and zero check. • Perform a constancy (long term drift) check. • Perform a linearity check (see notes below) • Investigate the effect of geometry on activity readings. Compare activity measured in glass vials and syringes. Perform using a pure gamma emitting radionuclide (e.g. ^{99m}Tc) and also using a gamma emitter with characteristic X-rays (e.g. ^{201}Tl) • Check for reproducibility of measurements on different equipment. o Review and comment on the dose calibrator surveys conducted

	by the Australian and New Zealand Society for Nuclear Medicine Technical Standards Committee (see http://www.anzsnm.org.au). • Discuss issues with measuring pure beta emitters (e.g. ^{90}Y, ^{89}Sr) and beta emitters with a non-negligible gamma-ray emissions (e.g.^{153}Sm) in standard calibrators.
Knowledge Sources	[1] AUSTRALIAN AND NEW ZEALAND SOCIETY OF NUCLEAR MEDICINE, Minimum quality control requirements for nuclear medicine equipment, Technical Standards Committee Place, Published.(1999) http://www.munatha.com.au/ANZAPNM/NM-QualityControl.pdf. [2] AUSTRALIAN AND NEW ZEALAND SOCIETY OF NUCLEAR MEDICINE, Measurement of I-123 Activity in Dose Calibrators, Place, Published.(1999) http://www.anzsnm.org.au/servlet/NM?page=47&name=Technical_Standards#documents. [3] ZANZONICO, P., Routine quality control of clinical nuclear medicine instrumentation: a brief review, J Nucl Med **49** 7 (2008) 1114-31. [4] EARLY, P.J., SODEE, D.B., Principles and Practice of Nuclear Medicine, 2nd edn, Mosby (1994). [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for Radioactivity Measurement in Nuclear Medicine, Technical Reports Series No. 454, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/TRS454_web.pdf. [6] VALLEY, J.F., BULLING, S., LERESCHE, M., WASTIEL, C., Determination of the efficiency of commercially available dose calibrators for beta-emitters, J Nucl Med Technol **31** 1 (2003) 27-32. [7] Manual for dose calibrator used in participant's department.
Notes	• This module requires handling of a large amount of activity. Make sure that proper radiation safety procedures are followed to minimise dose to yourself and other staff members. It may be useful for you to wear a personal electronic dosimeter to get an immediate reading of the dose received. • You will be changing the settings of the dose calibrator. Make sure you return the settings to the values prior to your work to ensure correct settings are used for subsequent calibration of clinical doses. • A long half-life calibration source such as ^{57}Co or ^{137}Cs should be available in the department to perform the constancy check. If possible, review the data already collected as part of normal dose calibrator QC with the long half-life calibration source. If a source is not available, discuss with your clinical supervisor. • The linearity check is very important when measuring high activity generator 99mTc as well as clinical doses. The hottest elution from the generator should be measured at regular intervals until the radioactivity measures ~ 10 MBq (~ 3 days). Plot a graph on semi log paper of

	activity reading vs. time. This should be linear. o Some thought will need to be given to obtaining a high enough source for the linearity measurement without impacting on the activity available for clinical studies. If the generator is delivered at least a day prior to its clinical use (e.g. generator for use from Monday is delivered on Friday), then it can be milked as soon as it arrives to provide a high activity source which can be measured over the next 3 days as it decays. Discuss with your mentor if there are problems in obtaining a source for this test. o If a large source is not available, then a source with an activity at least 2 to 3 times the maximum activity used clinically should be used for the linearity test. o The underestimation of activity at the highest activity level due to non-linearity should be calculated and comment made on whether the dose calibrator is suitable for the range of activities encountered in the department. o Check the plot for any discontinuities which may indicate changes in gain/reading as the dose calibrator changes between different activity reading ranges. o A large activity is handled for this test. Make sure appropriate radiation protection procedures are followed, including shielding, remote handling etc. If in doubt, check with your local radiation safety officer. o Some of these measurements may need to be done after hours or on the weekend. Make sure you follow your department's guidelines for handling activity after hours.
	Module 7 – Quality Control of Nuclear Medicine Equipment
	Sub-module 7.3 – QC of a Scintillation Probe and Well Counter
Objective	To become competent in quality control procedures for the scintillation probe and well counter
Prerequisite	Familiarity with hot lab procedures and radiation safety measures for the safe handling of radioactive sources.
Competencies Addressed	An understanding of the principles of operation of a scintillation probe and well counter and relevant QC procedures. The ability to perform basic QC procedures for non-imaging scintillation systems

Core Knowledge	• Familiarity with basic principles of scintillation probes and well counters • How to perform the following quality control checks: o Physical Inspection o Function of Scaler-timer/Rate meter o Energy Calibration o Energy Resolution (% FWHM) o Sensitivity o Counting Precision (Chi squared test) o Linearity of Energy Response o Integral Background Count Rate o Linearity of Activity Response o Preset Analyser Settings • Limits of acceptability • Setting action levels • Recommended frequency of checks • Importance of record keeping • Creating a control chart
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency • Critically review a department's QC procedures for scintillation probe and well counter • Perform the following QC tests with reference to IAEA TECDOC 602: o Physical Inspection o Function of Scaler-timer/Rate meter o Energy Calibration o Energy Resolution (% FWHM) o Sensitivity o Counting Precision (Chi squared test) o Linearity of Energy Response o Integral Background Count Rate o Linearity of Activity Response o Preset Analyser Settings • Analyse data obtained in the above tests and determine whether the results fit within acceptable limits • Propose appropriate corrective action if test results are unsatisfactory • Record results • Create control chart
Knowledge Sources	[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality control of nuclear medicine instruments, IAEA-TECDOC-602, IAEA, Vienna (1991). http://www-pub.iaea.org/MTCD/publications/PDF/te_602_web.pdf. [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for Radioactivity Measurement in Nuclear Medicine, Technical Reports Series No. 454, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/TRS454_web.pdf.

	[3] ZANZONICO, P., Routine quality control of clinical nuclear medicine instrumentation: a brief review, J Nucl Med **49** 7 (2008) 1114-31. [4] Also see references from Section 5.1
	Module 7 – Quality Control of Nuclear Medicine Equipment
	Sub-module 7.4 – QC of a Gamma Camera and SPECT
Objective	To become competent to perform and evaluate SPECT QC procedures.
Prerequisite	• Familiarity with basic principles of gamma camera design and the principles of SPECT image acquisition and reconstruction • Familiarity with the gamma camera/computer system used in the trainee's department and ability to acquire and reconstruct SPECT studies • Familiarity with hot lab procedures and radiation safety requirements for handling the sources required for the experiments
Competencies Addressed	An understanding of QC procedures for planar and SPECT devices. The ability to perform and evaluate typical (a) planar QC procedures including: spatial resolution and uniformity (integral and differential), (b) SPECT QC procedures including: spatial resolution, uniformity (integral and differential), COR, spatial resolution SPECT uniformity and tomographic image quality
Core Knowledge	• The ability to setup and carry out the required experiments. • The ability to generate a report, including description and presentation of experimental setup, results and conclusions from the results. • An understanding of the necessity and limitations of the QC procedures. • Knowledge of the underlying physical principles responsible for the experimental observations.
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency. • Critically review the department's gamma camera QC protocols with respect to the recommendations made in a national recommendations document such as the ANZSNM Technical Standards Subcommittee (TSS) document "Minimum quality control requirements for nuclear medicine equipment". o Write a report on your findings, including recommendations required to achieve compliance with the recommended minimum QC requirements. • Perform and write up the following planar QC tests using local national recommendations or the ANZSNM TSS document: o Quantitative high count uniformity

	♦ Examine the effects of total counts and matrix size on differential and integral uniformity o Intrinsic spatial resolution o Use a bar phantom and ^{99m}Tc point source. An estimate of the resolution in terms of Full Width at Half Maximum (FWHM) should be made from the measurement. o As an alternative to using a bar phantom, if a slit phantom is available, intrinsic resolution FWHM may be measured with the slit phantom. • Perform and write up the following SPECT QC tests: o Centre of Rotation measurement as specified by the manufacturer o SPECT spatial resolution as a function of the radius of rotation (ROR) ♦ Perform 2 SPECT acquisitions of a line source at the minimum ROR and at 20cm ROR. ♦ Collect planar views at each ROR. ♦ Reconstruct the SPECT acquisitions and calculate SPECT spatial resolution as a function of ROR. ♦ Compare the SPECT resolution with the static resolution for each ROR • SPECT Uniformity o Perform a SPECT acquisition of a uniform phantom filled with 99mTc o Reconstruct the data with attenuation correction. o Assess the reconstructed phantom uniformity. Describe any artefacts seen and provide quantitative estimates of the non-uniformities in the reconstructed slices. • Tomographic image quality o Perform a SPECT acquisition of a Jasczcak phantom filled with 99mTc. o Compare reconstructed images with previous studies of the same phantom to check that the system has maintained its capabilities for clinical imaging in terms of tomographic uniformity, contrast, and spatial resolution. **Reports** • Formal reports are to be written for each of the tasks performed as part of this competency. The reports should be properly structured and should contain as a minimum: o Methods section describing your experimental setup used, including details of phantoms, activity used, camera setup, collection parameters etc. Where appropriate, justification should be provided for your experimental method (e.g. why you selected particular matrix/pixel size, use of non-standard phantom etc.). Pictures or diagrams of your experimental setup are also encouraged. o Image processing and data analysis methods used including justifications for e.g. type of reconstruction filter, smoothing etc.

- Presentation of the results of the experiment. The results should be properly compiled and summarized to provide a picture of the performance of the gamma camera for this test.
- The results of your experiments should be fully discussed, including comparison with previous test results if available (e.g. acceptance test results), effect of not following e.g. NEMA protocol exactly, effect of different imaging conditions on results (e.g. radius of rotation on SPECT resolution), limitations of your experimental setup etc. Discussion should be supported by appropriate references. Conclusions should also be drawn regarding the suitability of the gamma camera for clinical use based on your measurements.
- It is important that you convey an understanding of the purpose, underlying principles, and limitations of the tests in your report to demonstrate your competency.
- Use of a note book is recommended for recording experimental details and results for later use when writing the report.

- While you are expected to research and devise appropriate methodology for the experiments, it is worthwhile to check your proposed experimental methods with your supervisor, particularly for tests with which you are unfamiliar.

- Specific Items to be addressed in your reports:

Review of QC Procedures:

- There might be valid differences between the procedures used in your department and the national recommendations, and in fact tests carried out might even be more appropriate for your particular equipment. If tests differ from local national or TSSC recommendations, but are considered appropriate, then this should be stated and reasons given why the current tests and procedures should not be changed.

Quantitative High Count Uniformity:

- Based on the results from the effects of total counts and matrix size on uniformity, discuss whether your current procedure uses appropriate matrix size and total counts. If not, what changes are required?

Intrinsic Spatial Resolution:

- Discuss whether the measured resolution is acceptable for this type of gamma camera.
- If a bar phantom is used to estimate resolution, discuss the limitations of this method for estimating FWHM.

SPECT QC Tests:

- Indicate whether the centre of rotation measurements are outside the limits specified by the manufacturer for this camera.
- Indicate what is an acceptable degradation in resolution between SPECT and planar measurements at the same distance/ROR. Discuss

	whether your measurement indicates that the camera meets this requirement. If not, what could cause the greater degradation in resolution seen with SPECT. ***SPECT Uniformity:*** • Would you expect a high count uniform phantom SPECT collection to be completely free of uniformity artefacts? • What level of non-uniformities would be acceptable? • Discuss the effect of noise on non-uniformity artefacts with relation to your high count phantom studies compared to lower count, high noise clinical studies. • Use the information in the reading material and your specific gamma camera manuals as guides for planning and performing the measurements. **Phantoms and Sources** • Unless otherwise specified, ^{99m}Tc should be used for all measurements. • The amount of activity used should be appropriate for the test. Guidance for activity to be used and count rates for tests can be found in the reading material. • Proper radiation safety procedures must be followed to avoid contamination of personnel and equipment. o Place phantoms/sources on protective covers (e.g. incontinence pads) to avoid contamination of equipment. o Make sure that phantoms do not leak – check with non-radioactive liquid first! o Make sure you are aware of and follow any local radiation safety guidelines. o Store phantoms/sources in appropriately shielded areas until decayed. • If phantoms such as a bar phantom or slit phantoms are not available in your department it may be possible to borrow them from other departments. Check this with your supervisor. • Some improvisation may be required if appropriate phantoms are not available: o For SPECT uniformity a cylindrical plastic bottle with a screw top seal would be suitable. o For SPECT resolution, any tubing with small internal diameter (< 2mm) may be used, providing it can be filled and sealed. Examples are: o Disposable 1 mL pipettes or hematocrit tubes filled and sealed at both end with plasticine. o Thin extension tubing taped to a ruler. **Quantitative Uniformity** • Review the NEMA specification for measurement of integral and differential uniformity. • Review camera manuals to see if software is provided to perform quantitative flood field uniformity assessments :– o if available is it done using NEMA methodology?

- NEMA specifies a particular pixel size and minimum count in the centre pixel for the uniformity test. As part of this exercise you are required to also investigate the effects of matrix size and total counts on the measured uniformity value.
  - Investigate whether the software will be suitable for investigating the variation of uniformity with matrix size (for instance some software will not analyse an arbitrary image matrix size, or will always collapse the image matrix to a 64x64 pixel size prior to analysis).
  - If software is not available or unable to perform the type of measurement required, the ImageJ QC plugins that can analyse images for uniformity are available – consult the plugin notes on the ImageJ website (http://rsbweb.nih.gov/ij/) for further information.

SPECT Uniformity

- Sufficient counts should be collected to avoid masking of non-uniformities by noise – consult reading material for appropriate activity in phantom and collection times.
- The data should be reconstructed with attenuation correction – uniform attenuation within the phantom may be assumed. Attenuation correction should be available on all clinical SPECT systems – if not available on your system, consult with your supervisor.
- Some experimentation with reconstruction filters will be required to provide best trade-off between noise and detection of non-uniformities. It is suggested that filters with a sharp roll-off (e.g. high order Butterworth filter) and resolution recovery filters are not used for this experiment. A Hann filter would be suitable.

SPECT Spatial Resolution

- Review effects of acquisition parameters such as pixel size and number of steps on the spatial resolution of reconstructed images. Plan acquisition parameters accordingly (spatial resolution is likely to be 6-8 mm FWHM for high resolution, low energy collimators at the minimum radius of rotation).
- SPECT resolution is to be measured without scatter. Thus line source should be suspended in air rather than placed on the patient SPECT bed. This can be achieved by taping the line source to the end of the bed or head holder.
- Line up the line source with the axis of rotation.
- Review principles of SPECT image reconstruction using filtered back projection and consider the most appropriate reconstruction filter to use for assessment of spatial resolution.
- Spatial resolution of line and point source images can be assessed by measuring FWHM of a profile drawn through the image. Consult your camera to see if tools for FWHM measurement are provided. If none are available, the ImageJ QC plugins provide a FWHM tool that may be useful - consult the plugin notes on the ImageJ website (http://rsbweb.nih.gov/ij/) for further information.

	Tomographic image quality • Compare uniformity, contrast and spatial resolution of the study with a similar study acquired previously (if possible at time of scanner installation). Comment on any differences in these parameters.
Knowledge Sources	[1] AUSTRALIAN AND NEW ZEALAND SOCIETY OF NUCLEAR MEDICINE, Minimum quality control requirements for nuclear medicine equipment, Technical Standards Committee Place, Published.(1999) http://www.munatha.com.au/ANZAPNM/NM-QualityControl.pdf. [2] FAHEY, F.H., Data acquisition in PET imaging, J Nucl Med Technol **30** 2 (2002) 39-49. [3] GRAHAM, L.S., "Scintillation camera performance and quality control", Nuclear Medicine, (HENKIN, R.E., et al., Eds), Mosby, (2006). [4] ZANZONICO, P., Routine quality control of clinical nuclear medicine instrumentation: a brief review, J Nucl Med **49** 7 (2008) 1114-31. [5] GROCH, M.W., ERWIN, W.D., Single-photon emission computed tomography in the year 2001: instrumentation and quality control, J Nucl Med Technol **29** 1 (2001) 12-8. [6] HINES, H., et al., Recommendations for implementing SPECT instrumentation quality control. Nuclear Medicine Section--National Electrical Manufacturers Association (NEMA), Eur J Nucl Med **26** 5 (1999) 527-32. [7] NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, NEMA Standards Publication NU 1-2001, Performance Measurements of Scintillation Cameras (2001). [8] Manufacturer's user manual for the gamma camera being used. [9] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for SPECT Systems, Human Health Series, 6, IAEA, Vienna (2009). http://www-naweb.iaea.org/nahu/dmrp/publication.asp.
Notes	This module requires the handling of radioactive sources. Make sure that proper radiation safety procedures are followed to minimise dose to yourself and other staff members. It may be useful for you to wear a personal electronic dosimeter to get an immediate reading of the dose received.
	Module 7 – Quality Control of Nuclear Medicine Equipment
	Sub-module 7.5 – QC of PET/CT Systems
Objective	To become competent in routine quality control procedures for PET/CT systems.

Prerequisite	Sub-module 2.2 Exposure from sealed and unsealed sources and the risk of contamination, Sub-module 9.1 Operation of a clinical acquisition and processing/reviewing workstation Sub-module 9.6 Image reconstruction, registration and fusion, and tracer kinetic modelling
Competencies Addressed	Familiarity with routine PET/CT QC procedures. The ability to perform routine QC procedures on a PET/CT system and to initiate appropriate corrective action when QC results reveal problems with the PET/CT system performance.
Core Knowledge	An understanding of the QC procedures required to maintain a PET/CT system in optimal operating condition.
Recommended Elements of Training	• Read and become reasonably familiar with the recommended reading material. • Summarize in writing the procedures in place at the trainee's department for routine PET/CT quality control. • Comment in writing on any differences between these procedures and those specified in the IAEA document 'Quality Assurance for PET and PET/CT Systems'. • Perform all scheduled routine PET/CT QC procedures in the department for a period of at least two weeks, under supervision. Write a report containing, for each procedure: o the purpose of the procedure. o the steps involved in performing procedure, including mention of any phantoms and how they are positioned o what parameters are evaluated and how o the frequency with which it is performed o where results are stored and how they can be accessed for review o what results were obtained during the period. o how results are interpreted. o what values are specified as acceptable by the manufacturer. o what actions should be taken when results fall outside the acceptable range.
Knowledge Sources	[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance for PET and PET/CT Systems, Human Health Series No. 1, IAEA, Vienna (2009). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1393_web.pdf. [2] ZANZONICO, P., Routine quality control of clinical nuclear medicine instrumentation: a brief review, J Nucl Med **49** 7 (2008) 1114-31. [3] PET system manufacturer's user manual, especially sections relating to routine QC procedures. [4] End-user documentation at the PET site describing local routine PET QC procedures.

	Module 7 – Quality Control of Nuclear Medicine Equipment
	Sub-module 7.6 – QC of Display and Hardcopy Devices
Objective	Understand factors affecting image quality on display monitors and hard copy devices.
Prerequisite	None
Competencies Addressed	(a) An understanding of quality control procedures for display and hard copy devices. (b) Knowledge of film and other hard copy properties and calibration Ability to perform QC for display and hard copy devices.
Core Knowledge	Familiarity with factors affecting image quality on display monitors and hard copy devices including: • film and other hard copy properties and calibration • display calibration • test patterns used for display and hard copy testing and calibration • the effects of display window settings and grey scale maps on image display
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency. • For each Nuclear Medicine workstation in the department display a suitable monitor test pattern (such as an SMTPE or TG18-QC test pattern) and o Follow the steps recommended in Resource 6 "Quality Assurance of Display Monitors" to assess monitor performance. Produce a suitable record sheet for each monitor assessed to summarise results. o If a densitometer is available, print the test pattern and measure the optical densities of grey scale squares on the hard copy of the test pattern. Comment on the linearity of optical density versus known intensity. o If paper hardcopy and/or films using a laser imager are normally produced, comment on o Loss of grey scale levels and range on hard copy compared to displayed image o Differences in colour (if colour printer) between hard copy and screen display o Experiment with the printer driver settings – can hard copy be improved by changing printer settings? (Note: record original printer settings prior to any changes so that original settings can be easily restored after you completed this task). • On a Nuclear Medicine clinical workstation o Investigate the effect of choosing different grey scale maps (e.g.

	linear, exponential, logarithmic, different gamma factors) and of altering display window settings (lower window level, upper window level) on a monitor test pattern image and on a variety of clinical images o Choose a clinical study that is normally displayed in colour (e.g. cardiac or brain) and display the images with the colour map your department uses normally. Investigate the effect of using different colour maps (including greyscale) on the image appearance. o Write a brief report on your findings. • Using the information, images and tools provided on the website given in resource 5, carry out the procedures described for Setting up your monitor on a PC computer to which you have access (Note: do NOT do this on a PC based gamma camera workstation). Preferably download the QuickGamma software and use it to investigate the interaction between its gamma adjustment and the black level adjustment on your monitor. o Write a brief report on your experiences including an estimate of the gamma for the monitor. **Reports** • Reports to be written for each of the tasks in this competency may be less formal than those required in other competencies. Inclusion of worksheets to summarise monitor performance, summaries in point form concerning the effects of gamma corrections on image, etc. are acceptable. However the written materials should still make clear the tasks that were performed and demonstrate your understanding of the areas covered in this competency.
Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Assessment of display performance for medical imaging systems, AAPM On-line Report 03, AAPM, College Park (2005). http://www.aapm.org/pubs/reports/OR_03.pdf Supplemental files available at http://www.aapm.org/pubs/reports/OR_03_Supplemental/. [2] AUSTRALIAN AND NEW ZEALAND SOCIETY OF NUCLEAR MEDICINE, Minimum quality control requirements for nuclear medicine equipment, Technical Standards Committee Place, Published.(1999) http://www.munatha.com.au/ANZAPNM/NM-QualityControl.pdf. [3] CURRY, T., DOWDEY, J., MURRY, R., Christensen's Physics of Diagnostic Radiology, 4th edn, Lippincott Williams & Wilkins (1990). [4] KORAN, N., Making fine prints in your digital darkroom - Monitor calibration and gamma, (2004), http://www.normankoren.com/makingfineprints1A.html. [5] NAWFEL, R.D., CHAN, K.H., WAGENAAR, D.J., JUDY, P.F., Evaluation of video grey-scale display, Med Phys **19** 3 (1992) 561-7 [6] Display_Monitor_Quality_Assurance, http://www.acpsem.org.au/index.php/radiologydocuments/doc_download/36-image-display-systems.html.

	[7] SMPTE Test Pattern or TG18-QC test pattern. These patterns are available on the web site [Alternatively, the SMPTE pattern can be obtained on the web at http://brighamrad.harvard.edu/research/topics/vispercep/tutorial.html and the TG18 pattern at http://deckard.mc.duke.edu/~samei/tg18.htm]
	Module 7 – Quality Control of Nuclear Medicine Equipment
	Sub-module 7.7 – QC of DXA Systems
Objective	To acquire the knowledge and skills to be able to perform QC tests on dual-energy X ray absorptiometry (DXA) units.
Prerequisite	None
Competencies Addressed	An understanding of the theory and operation of DXA equipment and the importance of QC and calibration in the accurate use of normal ranges The ability to perform QC of DXA equipment.
Core Knowledge	• The principles of general radiography • Dual energy x-ray absorptiometry principles. • Bone mineral densitometry concepts • DXA equipment components • Basic introduction to osteoporosis, bone physiology and risk factors • Radiation safety – shielding and patient dose. • Scan acquisition modes • Phantom calibration • Normal range, precision and reproducibility • Procedures for AP Spine, Femur/Dual Femur, Total Body, Forearm and LVA/Lateral spine.
Recommended Elements of Training	• Read and be reasonably familiar with items of core knowledge. • Perform a radiation survey of a DXA unit. • Perform routine QC on a bone mineral densitometer. • Perform calibration of a bone mineral densitometer.
Knowledge Sources	[1] Bone Densitometry: What is the Fundamental Basis - Tissue **Interaction?** http://www.chrislangton.co.uk/clip/html/Aspects%20of%20Osteoporosis/bone_densitometry.html. [2] BLAKE, G.M., WAHNER, H.W., FOGELMAN, I., The evaluation of osteoporosis: dual energy x-ray absorptiometry and ultrasound in clinical practice, 2nd edn, Martin Dunitz, London (1999). [3] BONNICK, S.L., LEWIS, L.A., Bone Densitometry for Technologists 2nd edn, Human Press, NJ, USA (2006). [4] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidelines for the use of DXA in measuring bone density and soft tissue body composition: A Handbook Rep. TBA, Vienna (2010).

	MODULE 8 - RADIONUCLIDE THERAPY USING UNSEALED SOURCES
Objective	To develop skills in the practical issues of individual radiopharmaceutical treatment and appropriate radiation safety requirements depending on the radionuclide used in therapy
Expected Duration	10% of total time
Sub-Modules	8.1 Understanding the principles of radionuclide therapy 8.2 Facility Design for radionuclide therapy 8.3 Treatment procedures 8.4 Selection of Radiopharmaceuticals for Nuclear Medicine Therapy 8.5 Dosimetry for radionuclide therapeutic procedure 8.6 Radiation safety precautions for therapy using unsealed radionuclide sources
Core Reading	[1] EMERALD CONSORTIUM, European Medical Radiation Learning Development (EMERALD), Student Training Workbook, Module 2, Physics of Nuclear Medicine, (2001), http://emitdictionary.co.uk/Emerald2/emit/Emerald2/nm_mod/workbook/nm_cover2.pdf. [2] LELE, R.D., Principles And Practice Of Nuclear Medicine And Correlative Medical Imaging, Jaypee brothers Medical Publishers Ltd, New Delhi (2009). [3] MARTIN, A., HARBISON, S.A., An Introduction to Radiation Protection, 5th edn, Oxford University Press (2006).
	Module 8 - Radionuclide Therapy Using Unsealed Sources
	Sub-module 8.1: Understanding the principles of radionuclide therapy
Objective	To acquire understanding the principles of radionuclide therapy
Pre-requisites	Module 2 Radiation Protection
Competency Addressed	An understanding of the principles of radionuclide therapy
Core knowledge	(a) Principles o Radiopharmaceuticals uptake and retention o Quantity of radiopharmaceuticals o Retention of radiopharmaceuticals o Consideration of Physical half-life o Tissue factors affecting radiopharmaceuticals uptake (b) Radionuclides for therapy o Alpha emitter o Beta emitter o Auger and Coster-Kronig electron emission processes

	(c) Regulatory Requirements and Guidelines o Local legislation and guidelines to be applied for the radionuclide therapy
Recommended Elements of Training	• List side effects from radioiodine treatment of thyroid diseases. • Classify into groups on the basis of the range of principal radiation emitted by the radionuclides. • Study the Local legislation and guidelines and compare them with the recommendations by ICRP, MIRD for radionuclide therapy • Describe physical characteristics (benefits and drawbacks) of one alpha emitter, one beta emitter and one radionuclide emitting Auger electrons used for therapy applications
Knowledge Sources	[1] HARBERT, J.C., ECKELMAN, W.C., NEUMANN, R.D., (Eds), Nuclear Medicine: Diagnosis and therapy, Thieme Medical Publishers, Inc, New York, (1996). [2] LELE, R.D., Principles And Practice Of Nuclear Medicine And Correlative Medical Imaging, Jaypee brothers Medical Publishers Ltd, New Delhi (2009).
	Module 8 - Radionuclide Therapy Using Unsealed Sources
	Sub-module 8.2: Facility Design for Radionuclide Therapy
Objective	To acquire knowledge on facility design for therapy using unsealed sources
Pre-requisites	Module 1 Clinical Awareness Module 2 Radiation Protection
Competency Addressed	An understanding of the principles of shielding design for the different radionuclide energies being used for therapeutic purposes The ability to design satisfactory radiation shielding for the different radionuclide energies used for therapeutic purposes
Core Knowledge	• Principles o The expected effective half life o Basic radiation protection Principle: Time, Distance, Shielding • Regulatory Requirements and Guidelines o Local legislation and guidelines to be applied to the design of radionuclide therapeutic facilities • Physical Design o Location e.g. the facility should be away from the public area and use of external wall can reduce the radiation shielding requirements o The expected length of hospital stay of the patient and the expected radiation dose rate from the patient o The design of excretory pathways

	○ The target design dose in accessible areas (e.g. the need for a dedicated shower/toilet for each room and a waste storage) ○ Dose constraints and shielding design goals, e.g. a constraint of 0.2 is often used for medical radiation workers ○ Attenuation of possible shielding materials for the radionuclide being used • Waste management ○ Management of patient's waste by "Delay and decay" method, e.g., the radioactive waste is held in storage until sufficient radioactive decay has taken place to allow safe discharge into the general environment ○ Waste discharge from the hospital to sewage at a point where the specific activity is acceptable to the regulatory authority.
Recommended Elements of Training	• Determine occupancy of surroundings of a radionuclide therapy room • Specify protective barriers i.e. walls, windows, doors, floors, ceilings, protective screens & shields for radionuclide therapy • Specify the shielding requirements for other penetrations, e.g. plumbing, electrical sockets • Specify correct warning signs at appropriate location • Document the management of a therapy patient. • Determine the maximum expected activity, e.g. the maximum expected number of patients per year in the treatment room. • Documentation of all assumptions, design, and specifications for future reference, and maintenance.
Knowledge Sources	[1] DELACROIX, D., GUERRE, J.P., LEBLANC, P., HICKMAN, C., Radionuclide and radiation protection data handbook 2nd edition (2002), Radiat Prot Dosimetry **98** 1 (2002) 9-168. [2] DRIVER, I., PACKER, S., Radioactive waste discharge quantities for patients undergoing radioactive iodine therapy for thyroid carcinoma, Nucl Med Commun **22** 10 (2001) 1129-32. [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality control of nuclear medicine instruments, IAEA-TECDOC-602, IAEA, Vienna (1991). http://www-pub.iaea.org/MTCD/publications/PDF/te_602_web.pdf. [4] LEUNG, P.M., NIKOLIC, M., Disposal of therapeutic 131I waste using a multiple holding tank system, Health Phys **75** 3 (1998) 315-21.
	Module 8 - Radionuclide Therapy Using Unsealed Sources
	Sub-module 8.3: Treatment Procedure
Objective	To understand the treatment protocols and rationale of the therapy
Pre-requisites	Module 1 Clinical Awareness Module 2 Radiation Protection Module 6 Radioactivity Measurements and Internal Dosimetry

Competency Addressed	An understanding of the purpose, principles and operational procedures of the radionuclide therapy Ability to manage patients appropriately from a radiation safety perspective both pre and post administration of the radionuclide
Core Knowledge	• Principles o Mechanisms of different types of radiopharmaceutical uptake used in therapy o Bio-distribution of radiopharmaceutical o Different types of radionuclide treatment and characteristics of specific radiopharmaceuticals for radionuclide therapy o Physical characteristics of radionuclide o Understand the concepts of absorbed dose, equivalent dose, cumulative absorbed dose and effective dose o Radiation protection principles (justification, optimization and limitation) • Procedures to be followed prior to treatment o Advise the patient and their attendance about preparations to follow before the treatment, during the treatment at home or in hospital and when discharged o Determine whether the treatment can be given as an inpatient or outpatient, where the dose should be administered and assess which ward/s are suitable for admission of patients for each type of treatment available o Ensure correct radiopharmaceutical and activity is ordered for the specific patient o Arrange for appropriate equipment, survey instruments, personal protection and dosimeters to be provided for the purpose of treatment o Assist the nuclear medicine physician to prepare information on the benefits and risks of the procedure for the patient to give his/her informed consent • Treatment procedures o Pre-treatment management o Protocols and procedures o Form of radionuclide to be administered to patient for therapy o Patient dose preparation and administration o Dose planning for treatment o Dose calculation of the appropriate radionuclide to be administered to the patient for therapy o Radionuclide therapy of distant metastases o Postoperative management of radionuclide therapy o Prepare a check-list of the whole procedure • Discharge o Safety of family members following discharge o Determination of the time frame when the patient can return to work or move in public environment o Discharge to a non-home environment

	• Long term advice o On future pregnancy. o Carcinogenesis e.g. the patient's follow-up and post treatment care issues. o Other probable complications or events/ symptoms to be aware of and be watchful of.
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency If Instructions, Information and Protocols for the tasks below already exist locally you should critically review them in comparison to national and international recommendations. • Make a list of radionuclide therapies routinely performed in your department. Briefly summarise three examples: one each by oral administration, intravenous infusion and intra-articular injection. Comment on rationale of the therapy, biodistribution of the radiopharmaceutical, radionuclide properties, therapeutic efficacy and possible adverse effects. • Prepare a protocol for nuclear medicine staff to unpack, dispense, label and administer a therapy dose to a patient for a therapy performed in your institution. • Prepare instructions for nursing staff caring for an elderly patient undergoing treatment with I-131 for thyrotoxicosis as an inpatient in a single room in a geriatric ward. Include observations, medication, patient hygiene, management of linen, meals, waste, access by visitors and other hospital staff, requests for medical tests, spills or episode of incontinence, use of electronic personal radiation dosimeter and significance of dosimeter readings. • In consultation with a nuclear medicine physician, prepare an Information pamphlet for patients having I-131 therapy for thyroid cancer. Include preparation for admission, what to do in hospital and what precautions to observe after discharge including return to work or planning a pregnancy.
Knowledge Sources	[1] CORMACK, J., TOWSON, J., FLOWER, M., "Radiation protection and dosimetry in clinical practice", Nuclear Medicine in Clinical Diagnosis and Treatment, (ELL, P.GAMBHIR, S., Eds), Churchill Livingstone (2004). [2] EUROPEAN COMMISSION, Radiation Protection 97, Radiation protection following iodine-131 therapy (Exposures due to outpatients or discharged inpatients) (1998). [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality control of nuclear medicine instruments, IAEA-TECDOC-602, IAEA, Vienna (1991). http://www-pub.iaea.org/MTCD/publications/PDF/te_602_web.pdf. [4] Go through local instructions, information pamphlets and protocols used in radionuclide therapy.

	Module 8 - Radionuclide Therapy Using Unsealed Sources
	Sub-module 8.4: Selection of Radiopharmaceuticals for Nuclear Medicine Therapy
Objective	To acquire knowledge on the fundamental principles of individual radiopharmaceutical treatment
Pre-requisites	Module 2 Radiation Protection Module 6 Radioactivity Measurements and Internal Dosimetry
Competency Addressed	(a) An understanding of the common indications and radiopharmaceuticals used for therapy in nuclear medicine (b) Familiarity with the wide range of diseases in which radionuclide therapy is being used and the selection of the appropriate radionuclide for the specific patient
Core Knowledge	• Principles o General principles of radionuclide therapy o Physical half-life, biological half-life (clearance) o Radiation quantities and units o Effective dose, equivalent dose, absorbed dose rate • Selection of a therapeutic radionuclide for therapy o Half – life o Locally absorbed radiations o Specific activity and chemical form • Concept of radionuclide therapy o Optimization of radiation dose and dose rate for ablation therapy o Criteria for therapeutic administration of radionuclide o Calculation of ablation dose • Selection of therapeutic radionuclide for different types of diseases o Thyroid cancer therapy with I-131 o Therapy for thyrotoxicosis with I-131 o I-131 MIBG therapy o I-131 Lipiodol therapy o Y-90 Microspheres o P-32 therapy for Myleproliferative therapy o Radionuclide therapy for painful bone metastases o Radiation Synovectomy for the knee with Y-90 silicate o In-111 Octreotide therapy o Monoclonal antibody therapy o Other therapeutic procedures
Recommended Elements of Training	• Carry out the clinical overview of each treatment procedure • Review the technical aspects of patient preparation and patient management • Assess the dose administration for different type of radionuclide therapy

	• Determine the benefits and side effects of therapy • Determine the risks associated with radionuclide therapy by considering the effects of radiation
Knowledge Sources	[1] CORMACK, J., TOWSON, J., FLOWER, M., "Radiation protection and dosimetry in clinical practice", Nuclear Medicine in Clinical Diagnosis and Treatment, (ELL, P.GAMBHIR, S., Eds), Churchill Livingstone (2004). [2] EUROPEAN COMMISSION, Radiation Protection 97, Radiation protection following iodine-131 therapy (Exposures due to outpatients or discharged inpatients) (1998). [3] LELE, R.D., Principles And Practice Of Nuclear Medicine And Correlative Medical Imaging, Jaypee brothers Medical Publishers Ltd, New Delhi (2009).
	Module 8 - Radionuclide Therapy Using Unsealed Sources
	Sub-module 8.5: Dosimetry for Radionuclide Therapeutic Procedure
Objective	To acquire knowledge on the estimation of radiation absorbed doses for therapy procedures involving radionuclide
Pre-requisites	Module 1 Clinical Awareness Module 2 Radiation Protection Module 6 Radioactivity Measurements and Internal Dosimetry
Competency Addressed	An understanding of the principles of internal dosimetry An ability to calculate the activity of the administered dose for therapy in nuclear medicine
Core Knowledge	• General considerations of bio-kinetics and dosimetry o Selection of radionuclides o Selection of organs and tissues for dose calculation • Other considerations o Maximum safe administered dose o Standard fixed dose o The ablation dose o Therapy and pregnancy e.g., the patient must be reassured both as to the effect of therapy on foetus and as to the effect of pregnancy upon the course of her diseases
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency. • Calculate the activity of ^{131}I to be administered in thyroid. by using the data for the thyroid uptake (for the particular patient) and from available clinical data. • Describe step by step the procedures for a patient undergoing treatment for hyperthyroidism.

	• Determine occupancy of surroundings of a radionuclide therapy facilities. • Carry out calculations for patient who are to be treated by considering uptake and biological half-life.
Knowledge Sources	[1] BERMAN, M., BRAVERMAN, L.E., BURKE, J., Summary of current radiation dose estimates to humans from I-123, I-124, I-125, I-126, I-130,I-131, and I-132 as sodium iodide, J Nucl Med **16** (1975) 857. [2] CORMACK, J., TOWSON, J., FLOWER, M., "Radiation protection and dosimetry in clinical practice", Nuclear Medicine in Clinical Diagnosis and Treatment, (ELL, P.GAMBHIR, S., Eds), Churchill Livingstone (2004). [3] HARBERT, J.C., ECKELMAN, W.C., NEUMANN, R.D., (Eds), Nuclear Medicine: Diagnosis and therapy, Thieme Medical Publishers, Inc, New York, (1996). [4] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Radiation Dose to Patients from Radiopharmaceuticals, Vol 18 nos. 1- 4, ICRP Publication 53, Pergamon Press, Oxford and New York (1988).
	Module 8 - Radionuclide Therapy Using Unsealed Sources
	Sub-module 8.6: Radiation Safety Precautions for Therapy Using Unsealed Radionuclide Sources
Objective	To be able to perform audit on radiation safety of unsealed radionuclide sources used in therapy
Prerequisite	Module 1 Clinical Awareness Module 2 Radiation Protection Module 6 Radioactivity Measurements and Internal Dosimetry
Competency Addressed	Familiarity with (a) all legislations, guidelines and international best practices to ensure radiation safety, before, during and after administration of radionuclide therapy (b) the chemical forms of therapy radiopharmaceuticals and how this would affect their distribution in the environment when excreted by the patient or if spilt from a container Ability to (a) apply radiation protection regulations to personnel, patients and members of the public associated with radionuclide therapy (b) communicate with the patient, staff and public about the risks associated with handling of high activity unsealed sources

Core Knowledge	• Principles
	  o Fundamentals of safety principles
	• Regulatory requirements and guidelines
	  o Local legislation and guidelines applied for the radionuclide therapy
	• Radiation safety for radionuclide therapy
	  o Advise the patient about preparations to follow before the treatment, during the treatment at home or in hospital and when discharged
	  o Radiation monitoring and radiation safety precautions
	  o Instruct ward staff on monitoring the patient, managing contaminated linen, food waste and other items and responding to medical emergencies
	  o Explain to ward staff the precautions to be observed for their own personal safety and the safety of other health care employees and visitors
	  o Instruct catering staff, cleaners and maintenance engineers who service therapy bedrooms and bathrooms
	  o Dispense the radiopharmaceutical to within ±10% of the prescribed activity and monitor its safe administration to the patient by the physician or technologist
	  o Determine when the patient may be discharged from hospital with respect to the radioactivity remaining in the body
	  o Radiation protection for workers and members of the public
	  o Dose limits for workers and members of the public
	  o Radiation monitoring and documentation associated in the procedure
	  o Ability to manage disused sources and waste
	  o Inventory control and waste management of radioactive material

Recommended Elements of Training	(1) Read, and be reasonably familiar with, the resource material recommended for this competency. (2) Document the safety issues and precautions aspects for the patients, staff and public. (3) Make a list of therapy in the treatment of thyroid cancer and thyrotoxic patients being used by ^{131}I. Also list the other radionuclide which are used for therapy. (4) Make a radiation safety manual of the above procedures. (5) Prepare a protocol for nuclear medicine staff to unpack, dispense, label and administer a therapy dose to a patient for a therapy performed in your institution. (6) Relate occupational exposures differences in different therapeutic radionuclide implementations. (7) Assess the risk and recommend precautions for pregnant women, children and staff who will be attending the patient. (8) Assess the risk of radiation from the patients undergoing radionuclide therapy to the members of the public. (9) Write a formal response to the following requests for information (for therapy with I-131). In each case, provide an estimate of effective dose, the corresponding risk, and one or more examples of a

	comparable exposure and/or a comparable risk. o for a parent who is undergoing radionuclide therapy, who has a 5-year old chil. o for a pregnant mother, who has to undergo therapy (dose to the mother/foetus). o for a pregnant registrar who is concerned about working with therapy patients. o for a nurse attending a patient who undergoes radionuclide therapy.
Reading List	[1] CORMACK, J., TOWSON, J., FLOWER, M., "Radiation protection and dosimetry in clinical practice", Nuclear Medicine in Clinical Diagnosis and Treatment, (ELL, P.GAMBHIR, S., Eds), Churchill Livingstone (2004). [2] EUROPEAN COMMISSION, Radiation Protection 97, Radiation protection following iodine-131 therapy (Exposures due to outpatients or discharged inpatients) (1998). [3] INSTITUTE OF PHYSICAL SCIENCES IN MEDICINE, Radiation Protection in Nuclear Medicine and Pathology Rep. 63 (1991). [4] MOULD, R.F., Radiation Protection in Hospitals, IOP Institute of Physics (1985). [5] CHERRY, S.R., SORENSON, J.A., PHELPS, M.E., Physics in Nuclear Medicine, 3rd edn, WB Saunders, Philadelphia (2003). [6] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Pergamon Press, Oxford and New York (1991). [7] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Pregnancy and Medical Radiation ICRP Publication 84, Pergamon Press, Oxford and New York (2000). [8] http://www.orau.org/ptp/infores.htm#dosimetry

	MODULE 9 - CLINICAL COMPUTING AND NETWORKING
Objective	To gain adequate knowledge and necessary skills to operate, upgrade and maintain clinical computer system including networks, and to effectively manipulate, analyse and process medical image data in different formats.
Expected Duration	10% of time.
Sub-Modules	9.1. Operation of a clinical acquisition and processing/reviewing workstation. 9.2. Computer system administration management. 9.3. First line computer system troubleshooting. 9.4. Computer image processing techniques. 9.5. Image analysis in a high level programming language (optional). 9.6. Image reconstruction, registration and fusion, and tracer kinetic modelling. 9.7. Standard image file formats used in nuclear medicine. 9.8. Computer networking, PACS, RIS and HIS. 9.9. Software validation: computer simulations, phantoms and clinical data.
Core Reading	[1] BARRET, H.H., SWINDELL, W.E., Radiological imaging, Wiley, New York (1980). [2] BURGER, W., BURGE, M.J., Digital Image Processing: An Algorithmic Introduction using Java, Springer (2008). [3] BURGESS, M., Principles of Network and System Administration, 2nd edn, J. Wiley & Sons (2000). http://www.iu.hio.no/~mark/sysadmin/SystemAdmin.html. [4] GELFAND, M.J., THOMAS, S.R., Effective Use of Computers in Nuclear Medicine, McGraw-Hill, New York (1988). [5] GONZALEZ, R.C., WOODS, R.E., Digital Image Processing, 3rd edn, Prentice Hall (2007). [6] HUANG, H.K., PACS: Basic Principles and Applications, Wiley-Liss (1998). [7] KAK, A.C., SLANEY, M., Principles of computerized tomographic imaging, IEEE Press, New York (1988). [8] LJUNGBERG M, S.S., KING MA, Monte-Carlo calculations in nuclear medicine, IOP Publishing, Bristol, Philadelphia (1998). [9] NATTERER, N., The mathematics of computerized tomography, Wiley, New York (1986).
	Module 9 - Clinical computing and networking
	Sub-module 9.1 - Operation of a Clinical Acquisition and Processing/Reviewing Workstation
Objective	To gain knowledge and skills required to operate clinical acquisition and reviewing/processing workstations (WS) to ensure their consistent and efficient use.

Prerequisite	• Basic familiarity with hardware components and architecture, principles underlying the design, functional features and implementation of a modern computer operating system. • Understanding of the role of a computer system for data acquisition and data processing/reviewing in a nuclear medicine service.
Competencies Addressed	An understanding of the basic characteristics of workstation operating systems and clinical software for image acquisition and processing. The ability to effectively use a workstation operating system and nuclear medicine clinical software to perform simple image display tasks, define scan protocols, acquire different type of scans, perform basic manipulation, analysis and processing of the common types of clinical data, transfer and archive clinical data.
Core Knowledge	• Understanding the essential hardware components of a workstation and effective use of a mouse, keyboard, windows, menus, shortcuts, utilities and help resources. • Operational knowledge of the available operating system(s) (e.g. Windows, Unix, Linux, Mac OS): design and implementation issues, working with files and directories, partitions, booting the system, analysis of a process, multiprocessing, multithreading, memory management techniques, process scheduling. • Understanding the underlying principles necessary to design clinical imaging protocols: static, dynamic, dual-isotope and multiple energy windows, gated, WB, SPECT, PET. • Understanding of basic image display and manipulation tasks: brightness and contrast adjustment, layout design, colour table choice, interpolation, resizing, cropping, padding, shifting, annotating, frame grabbing etc. • Operational knowledge and practical skills in image analysis and processing- ROI definition and manipulation, curve plotting and analysis, general spatial and temporal filtering, geometric transformations (operators), tomographic image reconstruction with appropriate selection of parameters: - essential features of processing WS. • Basic procedures related to data transfer and short/midterm image data archiving.
Recommended Elements of Training	• Read the resource material on the WS operating system, user instructions, manuals, guidance or other documentation accompanying the available WS-s. • Get accustomed to image display variables and ways of their altering. • Get familiarised with different image acquisition /processing protocols and obtain an adequate understanding of the meaning of different acquisition parameters that can be adjusted through the graphical user interface (GUI-s). • Generate a tree diagram of the workstation menu interface to get an overview of the workstation capabilities. • Explore and exercise clinical data transfer and archiving.

	• Work through the tasks listed in the competencies section above, referring to manuals and/or experienced users as required, until able to demonstrate familiarity with each task.
Knowledge Sources	**Specific**: (1) Vendor-supplied user instruction manuals and guidance (2) Textbooks and manuals on operating systems (3) In-house developed user instructions and protocols. **Textbooks and general references:** [1] ELL, P., GAMBHIR, S., (Eds), Nuclear Medicine in Clinical Diagnosis and Treatment, 3rd edn., Vol. Section 8, chapter 131, Churchill Livingstone (2004). [2] GELFAND, M.J., THOMAS, S.R., Effective Use of Computers in Nuclear Medicine, McGraw-Hill, New York (1988). [3] HENKIN, R.E., et al., (Eds), Nuclear Medicine, Mosby-Elsevier, Philadelphia, PA, (2006). [4] LEE, K.H., Computers in Nuclear Medicine: A Practical Approach, (2005).
	Module 9 - Clinical Computing and Networking
	Sub-module 9.2 – Computer System Administration Management
Objective	To achieve competence in performing necessary system administration tasks relevant for reliable functioning of the clinical nuclear medicine computer systems.
Prerequisite	Sub-module 9.1: Operation of a clinical acquisition and processing/reviewing workstation
Competencies Addressed	An understanding of computer system administration responsibilities and the essential commands, tools and utilities important for ensuring a consistent operation of clinical computer systems. The ability to perform necessary system administration tasks such as planning, installing, supporting, and maintaining the computer hardware, operating systems, clinical software and networking.
Core Knowledge	• Identification of the system hardware components and advanced understanding of their functioning and role: processor type and specification, motherboard, I/O cards, bus slots, RAM, disks and disk partitions, peripherals, power supply etc. • Working knowledge of different software types and versions: operating system, clinical software and network related issues. Documenting the configuration of the system. • Correct installation and customisation of the operating system, proper start-up and shutdown procedures, identifying CPU and memory usage of individual processes, checking available disk space, disc error checking, clean up and de-fragmentation. • Understanding and effective using of administrator privileges, adding or editing users/groups, ownership and permissions concepts and user preferences. • Effectively determining the space occupied by individual files and folders, identifying recently created or modified files, compressing and decompressing files and folders.

	• Understanding of the procedures to check basic network connectivity. • Installing, setting up and troubleshooting a printer. • Performing system backup and restore, image data retrieval and recovery. • Creation of hard copies.
Recommended Elements of Training	• Read the essential reference material on computer system administration that applies to the available computer system. • Obtain details on system hardware and software configuration and prepare the report with a structured description. • Discuss with the system administrator each of the following tasks, read related reference material and after either independent or supervised performance of the tasks, prepare a short document for selected three (3) of the following tasks: (i) computer system start-up and shutdown; (ii) install and update operating system or fine-tune it for specific clinical software requirements; (iii) learn about account/groups creation/removal and maintaining; (iv) study system rescue and repair; (v) access system and in-house documentation; (vi) access system administrator privileges and privileges of a user belonging to a certain group; (vii) explore installation/removal of peripheral devices; (viii) understand parameters of a printer configuration; (ix) study system backup and restore; (ix) install/configure/update virus protection software. • Consult resources above (or the system administrator if no information can be found) for information about each of the tasks in the list. Perform tasks and document the procedure followed in each case: (i) check available disk space and perform clean up (defragmenting, squeeze); (ii) determine space occupied by individual files and folders; (iii) identify recently created/modified files; (iv) determine CPU and memory usage of individual processes; (v) understand and interpret system log files; (vi) connect from a remote computer; (vii) study procedure to check basic network connectivity and means of diagnosing the network (e.g. ping, traceroute). • Prepare a short report that summarises the extent of the duties of a system administrator in a given organisation (NM service, section or department), and which demarcates between hers/his representative duties and the duties linked to a network/security administrator (analyst/specialist) and database administrator tasks. • Prepare a technical document describing the procedures used for backup and recovery of computer systems in the trainee's nuclear medicine department. • Discuss advantages and limitations of the above system backup procedures, with reference to alternative procedures and technologies that could offer advantages in terms of convenience, efficiency or cost over the existing procedures. • Prepare a report that shows knowledge of an available script language and describes the chosen operating system and scripting language, typical uses for scripts, syntactic and lexical rules,

	command line arguments, variables, command substitutions, decision making and loop constructs, and script tools.
Knowledge Sources	**Specific**: Vendor-supplied user documentation (including on-line manuals), hardware documentation and documentation for system administrators **Textbooks and general references:** [1] BURGESS, M., Principles of Network and System Administration, 2nd edn, J. Wiley & Sons (2000). http://www.iu.hio.no/~mark/sysadmin/SystemAdmin.html. [2] FRISCH, *Æ*., Essential Systems Administration, 3rd edn, O'Reilly (2001). [3] HUNT, C., TCP/IP Network Administration, O'Reilly and Associates (2002). [4] LIMONCELLI, T.A., HOGAN, C., CHALUP, S.R., The Practice of System and Network Administration, 2nd edn, Addison-Wesley (2007). [5] MUELLER, S., Upgrading and Repairing PCs, 18th edn, (2007). **Internet references:** [1] Backups and Disaster Recovery, The PC Guide, http://www.pcguide.com/care/bu/index.htm. [2] Antivirus, Firewall and Spyware Resources Computer Security Essentials for Everyone, http://www.antivirus-firewall-spyware.com/computer-virus-resources.html. [3] Computer Virus Resources, Cert Coordination Centre, Frequently Asked Questions about Computer Viruses, http://www.cert.org/other_sources/viruses.html. [4] Information about computer hardware technologies (http://www/pctechguide.com). e.g. disk technology http://www.pctechguide.com/04disks.htm.
	Module 9 - Clinical Computing and Networking
	Sub-module 9.3: First-line Computer System Troubleshooting
Objective	To expand the acquired knowledge on computer basics and system administration tasks with an ability to successfully eliminate common computer problems.
Prerequisite	Sub-module 9.1: Operation of a clinical acquisition and processing/reviewing workstation, Sub-module 9.2: Computer system administration management
Competencies Addressed	An understanding of the possible causes of a computer system malfunction. The ability to (a) rapidly recognize and troubleshoot common computer hardware, software and networking related problems. (b) design, schedule and implement computer system preventive maintenance

Core Knowledge	• Knowledge and adoption of important maintenance measures for the operating system and data, clinical software and hardware. • Consistent identification and differentiation between the above mentioned categories of computer problems. • Recognizing the signs of developing hardware problems. • Following appropriate instructions and protocols to diagnose and resolve each of the above classes of problem, involving other staff and external service providers as appropriate. • Familiarity with the weaknesses and strengths of common operating systems and applications software. • Accessing and interpreting system log files and error messages to aid diagnosis. • Use of a built-in documentation and diagnostic tools and utilities. • Utilization of the internet support resources to access bug reports and obtain and install patches and software updates. • Obtain updated information about computer viruses and use this information to implement appropriate virus protection measures, and respond effectively to virus occurrences.
Recommended elements of training	• Locate the sources of documentation and help facilities (on-line, manuals, guides, web-based sources, hardcopies etc.) for the various departmental computer systems and prepare a list of these sources, including URLs for web-based sources. • Research, using above reference material and other documentation sources, or asking your supervisor, the possible methods of diagnosing and counteract the following problems on each of the department's computer platforms: (i) hard disk errors; (ii) slowly running or frozen computer; (iii) inability to start an application; (iv) unusual behaviour of the software; (v) network errors, problems with connectivity and slow response.
Knowledge Sources	**Specific**: [1] Vendor-supplied user documentation (including on-line manuals), hardware documentation and documentation for system administrators. **Textbooks and general references:** [1] ELL, P., GAMBHIR, S., (Eds), Nuclear Medicine in Clinical Diagnosis and Treatment, 3rd edn., Vol. Section 8, chapter 131, Churchill Livingstone (2004). [2] HENKIN, R.E., et al., (Eds), Nuclear Medicine, Mosby-Elsevier, Philadelphia, PA, (2006). [3] HUNT, C., TCP/IP Network Administration, O'Reilly and Associates (2002). [4] Troubleshooting and Repair Guide, The PC Guide, (http://www.pcguide.com/ts/index.htm) **Internet resources:** [1] Antivirus, Firewall and Spyware Resources Computer Security Essentials for Everyone, http://www.antivirus-firewall-spyware.com/computer-virus-resources.html.

	[2] Computer Virus Resources, Cert Coordination Centre, Frequently Asked Questions about Computer Viruses, http://www.cert.org/other_sources/viruses.html. [3] Information about computer hardware technologies (http://www/pctechguide.com). e.g. disk technology http://www.pctechguide.com/04disks.htm. [4] BURGESS, M., Principles of Network and System Administration, 2nd edn, J. Wiley & Sons (2000). http://www.iu.hio.no/~mark/sysadmin/SystemAdmin.html.
	Module 9 - Clinical Computing and Networking
	Sub-module 9.4 - Computer Image Processing Techniques
Objective	To understand the underlying principles of image processing techniques applied to nuclear medicine images and be able to write and test the image processing routines in interactive programming environment and effectively apply them to selected clinical problems.
Prerequisite	Sub-module 9.1: Operation of a clinical acquisition and processing/reviewing workstation Sub-module 9.2: Computer system administration management
Competencies Addressed	An understanding of the underlying algorithms and programming language mandatory for developing simple image analysis/processing programs in an interactive programming environment. The ability to develop, test and document efficient image processing routines/applications in a high level programming environment and to utilize macro routines in the vendor's provided computer systems (environments), for selected clinical tasks.
Core Knowledge	• Thorough understanding of the data formats, constants, variables, array and structure, functions, subroutines, declarations, program decisions and loops employed in the available high level programming environment. *(Note: A high level programming environment, such as IDL, Matlab and Mathematica, as opposed to a high level programming language, refers here to the software packages or environments designed for data analysis, visualisation and cross/platform application development having a major advantage of compactness and large flexibility.)* • Writing and testing of the program code for 2D static and dynamic image data processing tasks by using the existing range of available functions/subroutines specific for the chosen programming environment: data read/write, display, normalisation, colour tables, point operators, neighbouring operators, geometric operators, Fourier domain operations , curve and surface plotting routines. • Thorough understanding of basic *image enhancement* functions typically applied in nuclear medicine imaging: contrast enhancement,

	noise suppression, general linear and non linear filtering and their properties. • Understanding of an *image restoration* concept and application of common filters such as Metz and Wiener. • ROI creation, manipulation and statistics, motion correction, time activity curve creation and analysis, curve smoothing, interpolation, function fitting. • Understanding of the environment in which the code should be written: starting and ending the macro program, windows, commands, macro language syntax, operators, data types, variables, program execution. • Basic understanding of the macro language statements to manipulate image data and curves: open/close, load, save, new data, plot/display statements.
Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this competency. • Become acquainted with a set of common image analysis and processing routines described and implemented in programming environments such as MATLAB, IDL, Mathematica or applications like ImageJ (Java) • Write a program to initialise necessary arrays, open and display image(s), perform simple addition, subtraction or multiplication with a constant, and display the final result of the operation. • Explore computer codes for interpolation and write code to perform interpolation of the opened and displayed image (e.g. 64 x 64) to 128 x128 pixels; investigate different properties of interpolation schemes (e.g. nearest neighbour, linear (bilinear), cubic (bicubic), B-spline, interpolation by convolution) • Read the literature and become reasonable familiar with different forms of contrast enhancement techniques; e.g. explore the histogram equalisation, design the algorithm, write the program in the chosen environment and test it with images having different levels of contrast. • Design a generalised scheme to perform low-pass filtering in spatial domain; test the variable dimension of a symmetric filtering kernel; implement different ways of handling the image edge (e.g. image padding: constant values, closest pixel value, mirrored values, wrapping-periodical repeating). • Identify in the literature the methods to measure MTF of the gamma camera system. Find out which analytical expressions for the MTF have been used for the construction of a Metz filter. • Search the literature for the description of the different linear and non-linear curve fitting algorithms; write a short program to fit the supplied time-activity curve representing the washout of activity from a: i) lung ventilation dynamic study or, ii) washout from a kidney following the administration of Lasix; describe different techniques of weighting the data points and estimate the uncertainties of the fit parameters.

	• Use macro utility to create the procedure to open file/image(s) (e.g. flood correction matrices, line source for estimating spatial resolution), customise screen display, colour bar and controls, reposition and resize window, define ROI(s), calculate important ROI parameters, create profile(s) and save numerical results and profiles in newly opened file. Learn procedures to create, write, run and debug the macro.
Knowledge Sources	**Textbooks and general references:** [1] BEVINGTON, P., ROBINSON, D.K., Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill (2002). [2] BURGER, W., BURGE, M.J., Digital Image Processing: An Algorithmic Introduction using Java, Springer (2008). [3] FISHER, R., DAWSON-HOWE, K., FITZGIBBON, A., ROBERTSON, C., TRUCCO, E., Dictionary of Computer Vision and Image Processing, (2005). [4] GONZALEZ, R.C., WOODS, R.E., Digital Image Processing, 3rd edn, Prentice Hall (2007). [5] GONZALEZ, R.C., WOODS, R.E., EDDINS, S.L., Digital Image Processing Using MATLAB, 2nd edn, Gatesmark Publishing (2009). [6] PRINCE, J.L., LINKS, J.M., Medical Imaging Signals and Systems, Pearson Prentice Hall, Upper Saddle River, NJ (2006). **Internet resources:** http://www.mathworks.com/products/matlab/ MATLAB is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and Fortran. http://www.ittvis.com/ProductServices/IDL.aspx IDL is solution for data analysis, data visualization, and software application development. http://www.wolfram.com/products/mathematica/index.html Mathematica- for computation, modelling, simulation, visualization, development, documentation, and deployment. http://homepages.inf.ed.ac.uk/rbf/HIPR2/ Image processing learning resources http://www.ph.tn.tudelft.nl/Courses/FIP/noframes/fip.html Fundamentals of image processing http://rsbweb.nih.gov/ij/ ImageJ, Image Processing and Analysis in Java

	Module 9 - Clinical Computing and Networking
	Sub-module 9.5 – Image Analysis in a High Level Programming Language (optional)
Objective	To achieve competency in developing simple computer programs for numerical data and curve manipulation, image analysis and processing in a high level language.
Prerequisite	Sub-modules 9.1, 9.2 and 9.4. (Operation of a clinical acquisition and processing/reviewing workstation, Computer system administration management, Computer image processing techniques)
Competencies Addressed	An understanding of the programming flowcharts and pseudo code, and the transition from this conceptual approach to a development of actual programs in a high level language. The ability to write simple, readable and efficient programs in a high level (procedural) language, to test new software and properly document the code.
Core Knowledge	• Familiarity with a concept of the commonly used tools that help developing and documenting program logic: flowcharts and pseudo code. • Understanding and efficient use of a chosen programming language: writing code, compiling and running, making code readable, batch execution, designing functions and procedures, program control, components of the language, debugging and error control, GUI building.
Recommended Elements of Training	• Choose a high level programming language which is available in the department. • Read, and be particularly familiar with, the reference material on: data types, variables, constants, operators: arithmetic, logical; comparison, concatenation etc., subroutine and functions, program control statements, error handling, arrays and collections, accessing array elements, sorting, strings, decision making, loops, basic input output of the data - all related to the chosen language. • Develop a basic algorithm and necessary data I/O steps in an illustrative form, to perform (i) a cubic spline interpolation for a given set of 1D data or (ii) an integration of a function by Gaussian quadratures or Simpson rule. Implement the above algorithm in the chosen language, write a source program, compile it and run. • Perform test runs and check the results with altered input data and parameters that can be adjusted. • Write a program in the chosen language that reads in a nuclear medicine image from a file (e.g. raw binary data), makes a transpose of a matrix representing the image, extracts and displays a

	sub-matrix and stores the sums of all the rows and all the columns in separate 1-dimensional arrays. This program should also find the maximum and minimum pixel values, total number of counts in the image, average and standard deviation. Consider defining and extracting the variable width line profile from the image. Enable writing of the data (image statistics and profile data) to a file that can be later opened and processed by a spread sheet program. (Not all of the functions should be implemented and tested). Comment and compare your small application with the typical NM tools in commercial programs for analysing image data. • Write a program that will open a flood image and do the calculation of the common integral and differential uniformity following the NEMA specifications. Consider UFOV and CFOV definitions, 9 point smoothing and histogram representation of a distribution of the differential non-uniformity parameter.
Knowledge Sources	**Textbooks**: [1] SHARP, J., Microsoft Visual C# 2008 Step by Step, Microsoft press, Redmond, WA (2008). [2] STROUSTRUP, B., The C+ + Programming Language, Addison Wesley (1997). [3] Free e-books on C# :http://www.onlinecomputerbooks.com/free-csharp-books.php [4] Free e-books on C++ :http://freeprogrammingebooks.org/free_ebook_c++_free_ebooks_c++/index.php **Internet resources:** http://www.rff.com/flowchart_shapes.htm concepts of logical flow of the process http://3d2f.com/programs/30-890-fchart-flow-chart-programming-download.shtml Flow Chart Visual Programming Language allows to run basic algorithms in a visual way
	Module 9 - Clinical Computing and Networking
	Sub-module 9.6 – Image Reconstruction, Registration and Fusion and Tracer Kinetic Modelling
Objective	To understand and to be able to perform complex nuclear medicine image processing techniques including image reconstruction, registration and fusion, compensation for different physical factors degrading reconstructed image quality, and fundamentals of tracer kinetic modelling.
Prerequisite	Sub-modules 6.2, 9.1, 9.4 (Formalism and application of internal dosimetry, Operation of a clinical acquisition and processing/reviewing workstation, Computer image processing techniques)

Competencies Addressed	An understanding of the algorithms implemented in the software routinely used in the resident's department to perform image reconstruction, registration, fusion and various compensation schemes for physical factors affecting the quality of SPECT and PET images. The ability to (a) perform image reconstruction and registration in clinical studies, and to propose, design and optimise/evaluate new reconstruction approaches and compensation schemes for different image degrading factors. (b) apply models for the analysis of the tracer kinetics
Core Knowledge	• Understanding basic concepts, terms and definitions related to *analytical* and *iterative* reconstructions: Radon transform, central slice theorem, frequency distance principle, Fourier re-binning, maximum likelihood expectation maximisation (ML-EM) reconstruction, OSEM and other acceleration schemes in statistical iterative reconstructions, regularisation etc. • Understanding differences, advantages and disadvantages of analytical and iterative (statistical/algebraic) reconstruction techniques. • Awareness of the different scatter, attenuation and depth dependent resolution correction schemes applicable to the analytical and iterative reconstruction techniques, their impact on reconstructed image quality and their importance and limitations in quantitative volume and activity measurements. • Knowledge of the practical implementation of software for merging anatomic and functional imaging: computer algorithms for image registration (feature and volume based), accuracy validation of the registered images (external markers, stereotactic frames, volume based SPECT to CT image registration, deliberate misalignment and realignment), visualisation techniques and clinical applications. • Acquaintance with a typical fusion display techniques-colour or alpha blending, side by side reviewing of the original images with synchronized cursors, interlaced pixel display, fused 3D data display, volume and surface rendering, 3D volume images and superimposed 2D orthogonal or oblique out-planes to show the functional information. • Understanding of single and multiple compartmental models, fitting of kinetic models, Patlak and Logan plots. • Understanding the concept of SUV values and factors which influence their values (partial volume effect, glucose level, choice of ROI, etc.)
Recommended Elements of Training	• Read and be reasonably familiar with papers and other sources of documentation describing these algorithms in detail. • Write a report describing the algorithms (e.g. filtered backprojection (FBP), maximum likelihood expectation maximisation (ML-EM, OSEM), including sufficient detail to demonstrate a clear understanding of the algorithms, underlying assumptions and their strengths and weaknesses compared to the alternative available algorithms.

	• Study the FBP algorithm (e.g. its implementation in DONNER library) and based on the FORTRAN computer code in translate and test the code in the chosen high level environment/language. • Explore properties and parameters of the built in radon/iradon function for Radon transform in MATLAB and test its behaviour with the provided Shep-Logan phantom: study the influence of the number of projections, matrix size, filter kernel, interpolation schemes and addition of noise, on the quality of reconstructed images; model your own 2D phantom with the available head phantom image and test radon/iradon function. • Following the literature develop algorithmically Chang attenuation or Sorenson attenuation correction scheme and consider how it can be implemented in the FBP reconstruction program previously developed in the environment such as IDL, Matlab or Mathematica. • Study the most frequently applied SPECT scatter correction schemes; chose one scheme (e.g. triple energy window, dual energy window); investigate different acquisition possibilities with the available camera systems and try to design a program in IDL, Matlab or Mathematica which would analytically reconstruct the scatter corrected data. Comment different approaches in scatter correction schemes employed in analytical and statistical reconstruction techniques. • In the chosen programming environment consider developing and testing a program that performs alpha blending of a background image with a selected foreground image. • Study tracer modelling and calculations of myocardial and/or cerebral blood flow in PET studies for different tracers, like O-15, Rb-82, NH3-N-13.
Knowledge Sources	**Textbooks and general references:** [1] BARRET, H.H., SWINDELL, W.E., Radiological imaging, Wiley, New York (1980). [2] BRACEWELL, R.N., Two-dimensional imaging, Prentice-Hall, Englewood Cliffs, NJ (1995). [3] DEANS, S.R., The radon transform and some of its applications, Wiley, New York (1983). [4] HERMAN, G.T., Image reconstruction from projections: the fundamentals of computerized tomography, Academic Press, New York (1980). [5] KAK, A.C., SLANEY, M., Principles of computerized tomographic imaging, IEEE Press, New York (1988). [6] NATTERER, N., The mathematics of computerized tomography, Wiley, New York (1986). **Papers and reports:** [1] BENTOURKIA, M., ZAIDI, H., Tracer kinetic modelling in PET, PET Clinics **2** 2 (2007) 267-277. [2] BROOKS, R.A., DI CHIRO, G., Principles of computer assisted tomography (CAT) in radiographic and radioisotopic imaging, Phys Med Biol **21** 5 (1976) 689-732.

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[10] RAHMIM, A., ZAIDI, H., PET versus SPECT: strengths, limitations and challenges, Nucl Med Commun **29** 3 (2008) 193-207.
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[12] TOWNSEND, D.W., CARNEY, J.P., YAP, J.T., HALL, N.C., PET/CT today and tomorrow, J Nucl Med **45 Suppl 1** (2004) 4S-14S.
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[15] ZENG, G.L., Image reconstruction--a tutorial, Comput Med Imaging Graph **25** 2 (2001) 97-103.

Attenuation and scatter correction:

[1] BEEKMAN, F.J., DE JONG, H.W.A.M., VAN GELOVEN, S., Efficient fully 3D iterative. SPECT reconstruction with Monte Carlo based scatter compensation, IEEE Trans. Med. Im. **21** (2002) 867–877.
[2] BEEKMAN, F.J., KAMPHUIS, C., FREY, E.C., Scatter compensation methods in 3D iterative SPECT reconstruction: a simulation study, Phys Med Biol **42** 8 (1997) 1619-32.
[3] BUVAT, I., RODRIGUEZ-VILLAFUERTE, M., TODD-POKROPEK, A., BENALI, H., DI PAOLA, R., Comparative assessment of nine scatter correction methods based on spectral analysis using Monte Carlo simulations, J Nucl Med **36** 8 (1995) 1476-88.

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Software:

http://www.eecs.umich.edu/~fessler/code/index.html reconstruction toolbox is a collection of open source algorithms for image reconstruction written in Matlab language. Iterative and non-iterative algorithms for tomographic imaging (PET, SPECT, X-ray CT). Iterative image restoration tools.

http://homepage.ntlworld.com/jfarrell/javactapp/index.html an intuitive understanding of image reconstruction. Features: phantom objects generate projection data that can be back projected; selection of filters, viewing angles, data bins, reconstruction field of view, animate back projection; reproject 8 or 16 bit images; save and load projection data; image windowing controls; visualize the projection data and sinograms.

http://www.mathworks.com/products/matlab/
MATLAB is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and Fortran.

http://www.ittvis.com/ProductServices/IDL.aspx
IDL is solution for data analysis, data visualization, and software application development.

http://www.wolfram.com/products/mathematica/index.html
Mathematica- for computation, modelling, simulation, visualization, development, documentation, and deployment.

ftp://cfi.lbl.gov/pub/reclbl/ image reconstruction from projections

ftp://cfi.lbl.gov/pub/rfit_4.4/ RFIT -Program for Fitting Compartmental Models to Region-of-Interest Dynamic Emission Tomography Data

Coxson PG, Salmeron EM, Huesman RH, Mazoyer BM. Simulation of compartmental models for kinetic data from a positron emission tomograph. *Comput Methods Progr Biomed.* 1992; 37:205-214.

COMKAT
http://comkat.case.edu
Muzic Jr RF, Cornelius S. COMKAT: Compartment model kinetic analysis tool. *J Nucl Med.* 2001; 42:636-645.

SPAMALIZE
http://brainimaging.waisman.wisc.edu/~oakes/spam/spam_frames.htm

Munich Heart Cardiac Analysis Package
http://www.munichheart.de

PMOD: Java Software for Image Quantitation and Kinetic Modelling
http://www.pmod.com

Receptor Parametric Mapping (RPM)
http://www.irsl.org/resources/rpm.shtml

	Module 9 - Clinical Computing and Networking
	Sub-module 9.7 – Standard Image File Formats Used in Nuclear Medicine
Objective	To be able to routinely use and manipulate medical image data in a range of image formats and to demonstrate an understanding of the relative advantages and disadvantages of the different image formats for specific applications.
Prerequisite	Sub modules 9.1, 9.2 (Operation of a clinical acquisition and processing/reviewing workstation, Computer system administration management)
Competencies Addressed	An understanding of the structure and properties of image file formats commonly utilized in nuclear medicine. The ability to read, display and manipulate medical image data provided in commonly used formats (Interfile 3.3, DICOM 3.0).
Core Knowledge	(1) Understanding of the significance of storage format options for integer, float, textual and other data. (2) The structure and characteristics of image file formats regularly used in nuclear medicine. (3) Definition and features of some standard bit-mapped image file formats, their strengths and weaknesses. (4) Awareness of the most commonly used digital image compression techniques. JPEG, fractal and wavelet compression.
Recommended Elements of Training	• Read and be reasonably familiar with the reference material recommended for this competency. • Study thoroughly the major characteristics of a DICOM and Interfile 3.3 format; explore the available modules /programs to convert from one image format to another (IDL, MATLAB, Mathematica) • Write a report which demonstrates an understanding of common file formats by including a detailed description of the most common formats used in medical imaging; contrasts their main features, advantages and disadvantages.
Knowledge Sources	[1] CLUNIE, D.A., DICOM Structured Reporting, Pixel Med Publishing, Bangor, PA (2001). http://www.pixelmed.com/. [2] OOSTERWIJK, H., GIHRING, P.T., DICOM Basics. OTech, Inc., Place, Published. (2002) http://www.otechimg.com/books.cfm?menu=pubs.

	[3] PIANYKH, O.S., Digital Imaging and Communications in Medicine (DICOM) - A Practical Introduction and Survival Guide, Springer (2008). http://www.springer.com /medicine/radiology/book/978-3-540-74570-9. http://medical.nema.org/ http://www.sph.sc.edu/comd/rorden/dicom.html DICOM viewers, servers/clients, resources and images **Papers**: [1] PECK, D., Digital Imaging and Communications in Medicine (DICOM): A Practical Introduction and Survival Guide, J Nucl Med **50** 1384 (2009). [2] TODD-POKROPEK, A., CRADDUCK, T.D., DECONINCK, F., A file format for the exchange of nuclear medicine image data: a specification of Interfile version 3.3, Nucl Med Commun **13** 9 (1992) 673-99.
	Module 9 - Clinical Computing and Networking
	Sub-module 9.8 – Computer Networking, PACS, RIS and HIS
Objective	To become familiar with the basic concept of PACS, its components, architecture, and implementation in a nuclear medicine environment and to become acquainted with the essentials of a radiology information system (RIS) and integrated hospital information system (HIS) to store, manipulate, and distribute patient data and images.
Prerequisite	Sub-module 9.1, 9.2, 9.3 (Operation of a clinical acquisition and processing/reviewing workstation, Computer system administration management, First line computer system troubleshooting)
Competencies Addressed	An understanding of PACS technology and acceptance testing procedures as well as the essentials of RIS and HIS. The ability to (a) participate in the maintenance of computer hardware and software that comprise a computer network, including the use, configuration and monitoring of active network equipment, (b) contribute to competent decisions related to selection of PACS that best meets the NM department needs based on its key characteristics and features. (c) The ability to effectively use NM workstations, servers and PACS linked to the local RIS or HIS and those linked to an external PACS system. *(The depth of the resident's knowledge to be acquired with this sub-module will be determined by the local conditions and organisational scheme. Some training institutions may have a number of different professionals dealing with networking, database and system administration, while in others these tasks will be shared or done almost exclusively by a medical physicist.)*

Core Knowledge	• Understanding of the essential network concepts: layers, models and architectures, types and sizes of networks, performance issues and concepts, network standards. • Essential network hardware components: physical media of connectivity-cabling, hubs, switches, bridges, routers, gateways, repeaters, protecting with firewalls. • Learning network features: file and printer sharing, application services, remote access, e-mail, network security • Understanding of the 7 layer OSI networking model and how data travels through the layers. • Understanding network communication protocols: TCP, UDP, TCP/IP, IP packets and IP addresses, sub netting, subnet masks • Other application layer common network applications encountered at the user level: DHCP, DNS, HTTP, Mail, FTP, Telnet, SMTP, NFS etc. • Knowledge of securing the network: account security, permissions, external threats, viruses and malicious software • Utilizing clinical networks to provide support for fast and efficient clinical report delivery to referring physician and to other authorized users involved in the patients' care taking into account patient data confidentiality. • Good understanding of the PACS infrastructure important for connectivity, reliability and security. • Understanding of the essential physical components of the PACS chain in NM department such as acquisition systems/cameras, network, intermediate computers, database servers and archival. • Sufficient knowledge to tailor the archiving system to the needs and specifications of an individual nuclear medicine service (procedural volume, data per study type, capacity, performance and cost). • Acceptance testing of PACS: network operation, installation and configuration, functionality under load, image quality and fault tolerance. • Basic acquaintance with requirements for the distribution of diagnostic images throughout the health enterprise: film replacement, timing performance, scalability and cost effectiveness, image quality, integration of the electronic medical record and security. • Understanding of the RIS features such as: (i) user access control , (ii) patient consent; (iii) patient demographics, update and relation to HIS; (iv) booking and scheduling, (v) work lists and folders (vi) reporting; (vii) RIS integration, integration between RIS and NM modalities, RIS and PACS, RIS and workstations. • Understanding of the functional requirements that RIS/HIS must possess to ensure the functionality and connectivity to NM modalities
Recommended Elements of Training	• Locate appropriate resource material and read the literature to be able to write briefly about the basics of each of the hardware components and protocols listed above for this competency. Read also about network management and network security.

	• Write a report on the ways which the network in a specific nuclear medicine department utilises these hardware components and protocols, and comment on network management and security issues/vulnerabilities of the network. • Based on the studied literature and assistance provided by local IT specialists and medical physicists, identify the current network infrastructure, make an assessment on the future network needs assuming potential growth of the service (e.g. new SPECT-CT system or 1-2 dedicated gamma cameras) and describe it in a report. • Study PACS system in the NM department and prepare a technical documentation that describes its major components and features. • Based on the available literature, design a short guidance that could serve as a reference document for performing acceptance testing of the PACS - recognise specific requirements and assign roles for different professionals. • Get acquainted with available PACS in the NM department, prepare a short description on the connection between the RIS and the PACS and identify the type of RIS-HIS integration modality. • Explore in a short report which additional information systems and databases are linked to the RIS/HIS and what important data is transferred to/from it.
Knowledge Sources	**Textbooks and general references:** [1] PERLMAN, R., Interconnections: Bridges, Routers, Switches, and Internetworking Protocols, 2nd edn, Professional Computing, Addison-Wesley (1999). [2] HUANG, H.K., PACS: Basic Principles and Applications, Wiley-Liss (1998). [3] THE ROYAL COLLEGE OF RADIOLOGISTS, Radiology Information Systems, Place, Published. (2008) http://www.rcr.ac.uk/docs/radiology/pdf/IT_guidance_RISApr08.pdf **Papers and reviews:** [1] HORII, S.C., BIDGOOD, W.D., JR., PACS mini refresher course. Network and ACR-NEMA protocols, Radiographics **12** 3 (1992) 537-48. [2] STEWART, B.K., PACS mini refresher course. Local area network topologies, media, and routing, Radiographics **12** 3 (1992) 549-66. [3] BADANO, A., AAPM/RSNA tutorial on equipment selection: PACS equipment overview: display systems, Radiographics **24** 3 (2004) 879-89. [4] BROWN, P.H., KRISHNAMURTHY, G.T., Design and operation of a nuclear medicine picture archiving and communication system, Semin Nucl Med **20** 3 (1990) 205-24. [5] CHOPLIN, R.H., BOEHME, J.M., 2ND, MAYNARD, C.D., Picture archiving and communication systems: an overview, Radiographics **12** 1 (1992) 127-9. [6] MILLER, T.R., JOST, R.G., SAMPATHKUMARAN, K.S., BLAINE, G.J., Hospital-wide distribution of nuclear medicine

	studies through a broadband digital network, Semin Nucl Med **20** 3 (1990) 270-5. [7] ROSSET, A., RATIB, O., GEISSBUHLER, A., VALLEE, J.P., Integration of a multimedia teaching and reference database in a PACS environment, Radiographics **22** 6 (2002) 1567-77. [8] SAMEI, E., et al., AAPM/RSNA tutorial on equipment selection: PACS equipment overview: general guidelines for purchasing and acceptance testing of PACS equipment, Radiographics **24** 1 (2004) 313-34. **Web books:** http://www.tcpipguide.com/free/t_toc.htm The TCP/IP Guide http://learnat.sait.ab.ca/ict/txt_information/Intro2dcRev2/index.html Introduction to Data Communications
	Module 9- Clinical Computing and Networking
	Sub-module 9.9 – Software Validation: Computer Simulations, Phantoms and Clinical Data
Objective	To become familiar with the underlying principles of MC simulations, the use of generic and nuclear medicine specific Monte Carlo simulation packages for generating simulated image data, and to understand the importance of its comparison with physical phantom measurements and value in improving clinical imaging studies.
Prerequisite	Sub module 9.1, 9.2, 9.4 (Operation of a clinical acquisition and processing/reviewing workstation, Computer system administration management, Computer image processing techniques)
Competencies Addressed	An understanding of the components of a Monte Carlo simulation method: computer generated phantoms, models of the imaging process, fast computational methods, and the use of physical phantoms and methods of clinical validation The ability to (a) perform MC simulations with one of the NM related simulation programs and properly interpret results. (b) assist in designing a clinical validation study with a goal to bring an appreciable improvement in image quality, quantitative accuracy and image reader's confidence.
Core Knowledge	• Understanding of the concepts related to MC simulations: random number generators, sampling, probability distributions, photon histories, modelling the object (analytical shapes and vowelized geometries) containing radionuclide, collimators, photon detection in the crystal, binning, projection formation, variance reduction techniques. • Methods of a simulator validation-comparison with the physical

	phantom measurements. • Awareness of the range of available mathematical phantoms, their complexity, limitations advantages and disadvantages: Zubal, Cristy/Eckerman, Hoffman, VIP-Man, MCAT, NCAT and the ability to use phantoms to assess image quality for SPECT reconstruction algorithms and physical factor compensation schemes testing. • Familiarity with common physical phantoms used for software and algorithm validation: Hoffman 3D brain phantom, non-uniform Thorax phantom, dynamic phantoms. • Value of computer simulations and physical phantom measurements to improve image quality in nuclear medicine. • Knowledge of image fusion checking with phantoms and software. The application is used to fuse SPECT and CT data in SPECT/CT systems and also PET and CT data for PET/CT systems but can also be used to merge SPECT or PET data with MRI. In addition, the fusion application can be used to properly align older with current studies.
Recommended Elements of Training	• Read and be familiar with essential reference material • Use an already installed MC simulation programme or install and set up one of the freely available MC programs (e.g. Simind, SimSET) • Study one of the publications provided in the reading list and prepare a short report describing the techniques used for the simulator validation; assess the comprehensiveness of validation, and the range of parameters measured. • Test the selected program with tutorials to create simple images of Tc-99m point sources in a cylindrical water phantom; explore energy spectrums obtained with varying phantom diameters, modified energy windows and different level of complexity involved in a simulation. • Test the selected program to create simulated SPECT projections of available phantoms. Check simple scatter and attenuation correction with simulated sets; import projection data to into a clinical workstation to utilise the available reconstruction and image processing routines. Describe results. • Search the literature and identify a scientific paper that describes for example, a novel reconstruction algorithm or reconstruction acceleration scheme, physical factor correction scheme or simultaneous emission/transmission imaging approach; describe the computer simulations and physical phantoms measurements, parameters and indices used for validation and assessment of accuracy and general image quality metrics (e.g. profiles, contrast, mean square error (MSE), normalised MSE (NMSE), NSD etc.). • Find a publication in which ROC analysis was used to perform an analysis or features comparison of e.g. clinical SPECT images with different properties resulting from altered physical factor correction schemes, different filtering approach or reconstruction acceleration technique. Analyse it and write a short report which demonstrates an understanding of ROC methodology with a discussion on the limitations and results.

Knowledge Sources	[1] BUVAT, I., CASTIGLIONI, I., Monte Carlo simulations in SPET and PET, Q J Nucl Med **46** 1 (2002) 48-61. [2] LJUNGBERG, M., STRAND, S.E., KING, M.A., Monte-Carlo calculations in nuclear medicine, IOP Publishing, Bristol, Philadelphia (1998). [3] ZAIDI, H., Relevance of accurate Monte Carlo modelling in nuclear medical imaging, Med Phys **26** 4 (1999) 574-608. **NM specific codes:** http://depts.washington.edu/simset/html/simset_main.html SIMSET University of Washington, Division of Nuclear Medicine, SimSET, Home Page http://www.radfys.lu.se/simind/ SIMIND Medical Radiation Physics, Department of Clinical Sciences, Lund, Lund University, SE-221 85 Lund, SWEDEN http://opengatecollaboration.healthgrid.org/ GATE **General purpose code/ simulation packages:** http://www.irs.inms.nrc.ca/EGSnrc/EGSnrc.html EGSnrc distribution site, National Research Council Canada http://mcnp-green.lanl.gov/ MCNP - A General Monte Carlo N-Particle Transport Code http://geant4.web.cern.ch/geant4/ Geant4 is a toolkit for the simulation of the passage of particles through matter **Publications-phantoms:** (1) IG Zubal, CR Harrell, EO Smith, Z Rattner, G Gindi and PB Hoffer, Computerized 3-Dimensional Segmented Human Anatomy Med. Phys. 21(2): 299-302, 1994. (2) http://dmip1.rad.jhmi.edu/xcat/ Medical Imaging Simulation Techniques and Computer Phantoms. **Publications-validation:** (1) De Vries DJ, Moore SC, Zimmerman RE, Mueller SP, Friedland B, Lanza RC. Development and validation of a Monte Carlo Simulation of photon transport in an Anger camera. IEEE Trans Med Imaging 1990;9:430-8. (2) Narita Y, Eberl S, Iida H, Hutton B, Braun M, Nakamura T et al. Monte Carlo and experimental evaluation of accuracy and noise properties of two scatter correction methods for SPECT. Phys Med Biol 1996;41:2481-96. (3) Yanch JC, Dobrzeniecki AB. Monte Carlo simulation in SPECT: complete 3D modelling of source, collimator and tomographic data acquisition. IEEE Trans Nucl Sci 1993;40:198-203. (4) Moore SC, El Fakhri G. Realistic Monte Carlo simulation of Ga- 67 SPECT imaging. IEEE Trans Nucl Sci 2001;48:720-4. **ROC analysis:** (1) Metz CE Basic principles of ROC analysis. Seminars in Nuclear Medicine, 8, 283-298, 1978. (2) http://www-radiology.uchicago.edu/krl/rocstudy.htm ROC Analysis in Medical Imaging.

	MODULE 10 – CLINICAL APPLICATIONS
Objectives	To develop an understanding of and familiarity with commonly performed clinical procedures in nuclear medicine.
Expected Duration	10% of total time
Sub-Modules	10.1 Protocols for routine clinical procedures 10.2 Common artefacts in clinical images 10.3 Analysis of common clinical studies and sources of error 10.4 Principles and physiological basis for common clinical studies 10.5 Developing clinical protocols for the estimation of patient dosimetry 10.6 Optimization 10.7 The physiological basis of PET imaging
Core Reading	[1] BERNIER, D.R., CHRISTIAN, P., LANGAN, J.K., (Eds), Nuclear Medicine, Technology and Techniques, Mosby, (2003). [2] EARLY, P.J., SODEE, D.B., Principles and Practice of Nuclear Medicine, 2nd edn, Mosby (1994). [3] ELL, P., GAMBHIR, S., (Eds), Nuclear Medicine in Clinical Diagnosis and Treatment, 3rd edn., Vol. Section 8, chapter 131, Churchill Livingstone (2004). [4] HENKIN, R.E., et al., (Eds), Nuclear Medicine, Mosby-Elsevier, Philadelphia, PA, (2006). [5] SANDLER, M.P., COLEMAN, R.E., Diagnostic Nuclear Medicine, 4th edn, Lippincott Williams and Wilkins, Philadelphia (2003).
	Module 10: Clinical Applications
	Sub-module 10.1: Protocols for Routine Clinical Procedures
Objective	To be able to understand and justify the technical factors of the clinical procedures used in the Nuclear Medicine Department.
Prerequisite	Familiarity with the principles of operation and use of the gamma camera and SPECT systems in the trainee's Department
Competencies Addressed	Familiarity with the effect of technical factors and acquisition protocol on the final result of a clinical procedure.

Core Knowledge	• The technical factors which influence the acquisition, processing and display of the required clinical information. • Ways to optimise the acquisition parameters to maximize the clinical information. • Ways to optimise the processing parameters to maximize the clinical information. • The ability to design and implement a new clinical procedure based on published techniques.
Recommended Elements of Training	• Read, and be reasonably familiar with, the essential resource material recommended for this competency (trainee may be orally examined on aspects of this at a later stage). • Identify the technical factors which influence the acquisition, processing and display of the required clinical information. • Optimise the acquisition parameters to maximize the clinical information. • Optimise the processing parameters to maximize the clinical information. • Design and implement a new clinical procedure based on published techniques. • Undertake the following tasks: (1) Choose 5 different studies from the following: bone, lung, brain SPECT, gated blood pool, renal blood flow and function, infection/tumour, gastroenterology, endocrinology and post-therapy. The 5 studies must include a whole body, a dynamic and a SPECT, and at least 3 different radionuclides. For each study, describe your department's clinical protocol and compare this protocol with the corresponding protocol recommended by the Society of Nuclear Medicine. In the report include details and justification of o clinical indications o patient preparation o choice of radiopharmaceutical o (in-house) preparation and QC of radiopharmaceutical o activity administered and method of administration o camera type (single or dual-head, size of FoV, inter head angle) and collimators o energy window(s) o images to be acquired (statics, whole body, dynamic, SPECT, gated) o patient positioning o timing of imaging (how long after administration, phase parameters if dynamic) o acquisition parameters (matrix size, duration or counts in image, etc.) o for SPECT, number of images, time per image, step-and-shoot or continuous o image processing required for final display (2) In association with the supervisor select a study not currently

	performed in the department, and, using the above resources and/or recent scientific articles, design a clinical protocol for use in your department. The new protocol should include the above list of technical factors.
Knowledge Sources	**Essential** [1] EUROPEAN ASSOCIATION OF NUCLEAR MEDICINE, Procedure Guidelines, http://www.eanm.org/eanm.php?kopf=head/hd_scien_guidelines.html&worte=scientific_info/scien_guidelines.html. [2] SOCIETY OF NUCLEAR MEDICINE, Procedure Guidelines, http://www.snm.org/policy/new_guidelines_1.html. [3] Procedure Manual of the Trainee's Department **Reference** [1] BERNIER, D.R., CHRISTIAN, P., LANGAN, J.K., (Eds), Nuclear Medicine, Technology and Techniques, Mosby, (2003). [2] DISTANT ASSISTED TRAINING PROGRAMME, Distance assisted training for nuclear medicine technologists. Module 1 Unit 3A, www.datnm.org. [3] EARLY, P.J., SODEE, D.B., Principles and Practice of Nuclear Medicine, 2nd edn, Mosby (1994). [4] ELL, P., GAMBHIR, S., (Eds), Nuclear Medicine in Clinical Diagnosis and Treatment, 3rd edn., Vol. Section 8, chapter 131, Churchill Livingstone (2004). [5] HENKIN, R.E., et al., (Eds), Nuclear Medicine, Mosby-Elsevier, Philadelphia, PA, (2006). [6] SANDLER, M.P., COLEMAN, R.E., Diagnostic Nuclear Medicine, 4th edn, Lippincott Williams and Wilkins, Philadelphia (2003). [7] Local department's Procedure Manual
	Module 10: Clinical Applications
	Sub-module 10.2: Common Artefacts in Clinical Images
Objective	To be able to correctly identify common artefacts in nuclear medicine images and to recommend appropriate preventative and remedial action.
Prerequisites	Familiarity with the principles of operation and use of the gamma camera and SPECT systems in the trainee's Department.
Competencies Addressed	Familiarity with common image artefacts, their causes, and how to deal with them. The ability to identify artefacts in nuclear medicine images, identify their probable causes and undertake remedial action.
Core Knowledge	Common image artefacts, their causes, and remedial action.

Recommended Elements of Training	• Read, and be reasonably familiar with, the resource material recommended for this sub-module. • Identify artefacts in nuclear medicine images • Identify probable causes of these artefacts • Undertake remedial action to correct the problem giving rise to the artefact. • Optimise the data acquisition procedures to prevent the artefacts occurring • Undertake the following tasks: (1) **Influence of patient motion on SPECT studies**. Use a patient acquisition (projection) dataset for which there is no known motion (use the sinogram and SPECT cine to confirm this). Manually move certain images in the data set and reconstruct the data. Use any available software tools, as well as a visual comparison, to identify any artefacts in the reconstructed images. Experiment separately with movement in the x and y planes. It is suggested that either brain and/or myocardial SPECT studies be examined. Report and comment on your findings. (2) **Influence of inappropriate collimator selection on image contrast**. (a) Use the supplied images of a contrast phantom (a Perspex step wedge) imaged in a solution of ^{67}Ga and acquired using both MEAP and LEHR collimators. Compare the measured contrast in the different images. (b) Similarly use the supplied images of a line source filled with ^{67}Ga and acquired with the different collimators. Measure the FWHM and FWTM of the LSF and compare. (c) Use the supplied images of a point source of ^{131}I acquired using LEAP, LEHR, MEAP and HEAP collimators. Comment on the differences. (d) Use the supplied images of the contrast phantom of part a, which have been acquired using ^{99m}Tc instead of ^{67}Ga and using a ^{99m}Tc window with the LEAP, LEHR, MEAP and HEAP collimators. Record the measured contrast. A Petri dish containing a solution of ^{99m}Tc was imaged with the 4 collimators. Use the supplied images to calculate the relative sensitivity of the collimators for ^{99m}Tc. When might a MEAP collimator be used to image ^{99m}Tc? **(3) Influence of inappropriate energy window settings.** (a) Use the supplied images of the ^{67}Ga contrast phantom acquired using both 2 and 3 energy windows and an image collected with a ^{99m}Tc window and compare the images. (b) Use the supplied flood images of a ^{57}Co sheet source. 4M count flood images were acquired with a 15% window which was initially centred on the photo peak and then positioned above and below the peak in 3 keV increments. Determine the integral and differential uniformity on each images set and visually review the images. Comment on any changes observed.

	(4) Influence of collimator non-uniformity on SPECT reconstructed uniformity (a) Use a ^{57}Co sheet source or a ^{99m}Tc flood tank to acquire a 4 M count flood image with a LEHR collimator and compute the integral and differential uniformity. (b) Fill a cylindrical phantom such as a Jaszczak phantom with a well mixed solution of ^{99m}Tc (300-400 MBq) and acquire a SPECT study. Use the acquisition protocol recommended by the AAPM (ref 3). Assess the reconstructed uniformity both visually and quantitatively using the AAPM method (protocol 3 of ref 3) (c) Firmly attach to the surface of the collimator a disc (approx. 2 cm diameter) of a material which will attenuate the ^{99m}Tc photons by no more than 2%, and repeat steps a and b. The "non-uniformity" should initially be placed near the centre of the FOV and then at increasing 5 cm distances away from the centre. (d) Comment on any changes observed. **(5) Clinical artefacts** Review a series of images (both clinical and QC) and suggest possible causes for the artefacts observed. Compare your suggestions with the answers provided by the supervisor.
Knowledge Sources	[1] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Quantitation of SPECT Performance, Report of AAPM Nuclear Medicine Committee Task Group 4, AAPM Rep. 52, New York (1995). http://www.aapm.org/pubs/reports/rpt_52.PDF. [2] DWAMENA, B.A., "Artefacts ", Nuclear Medicine Imaging: A Teaching File, (HABIBIAN, M.R., DELBEKE, D., MARTIN, W.H.SANDLER, M.P., Eds), Lippincott Williams & Wilkins, Philadelphia, PA, (1999). http://jnm.snmjournals.org/cgi/content/full/42/1/176. [3] HOWARTH, D.M., FORSTROM, L.A., O'CONNOR, M.K., THOMAS, P.A., CARDEW, A.P.S.E., Patient-related Pitfalls and Artefacts in Radionuclide Imaging, Seminars in Nuclear Medicine **26** 4 (1996). [4] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Control Atlas for Scintillation Camera Systems, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1141_web.pdf.

	Module 10: Clinical Applications
	Sub-module 10.3: Analysis of common clinical studies and sources of error
Objective	Analyse a range of common clinical studies using software provided by the gamma camera manufacturer/supplier, or through in-house programs.
Prerequisite	Familiarity with the types of studies and methods used for analysing these studies in the trainee's department.
Competencies Addressed	Familiarity with sources of error in clinical procedures, their impact on the patient and how to validate clinical procedures.
Core Knowledge	• The ability to determine whether particular clinical analyses have been validated in the clinical arena, and limitations of the validation studies. • Familiarity with the sources of error which may arise during the analysis of nuclear medicine studies. • An understanding of the effect of the scan result on patient management and the consequences of an inaccurate scan result
Recommended Elements of Training	• Read, and be reasonably familiar with, the essential resource material recommended for this competency. • For a range of study types: o determine whether the study has been validated in the clinical arena, and limitations of the validation study. o investigate the effect of the scan result on patient management. o assess consequences of an inaccurate scan result. • Undertake the following tasks: Select an acquired study for each of the following three scan types: Myocardial SPECT, gated blood pool, and renal blood flow and function. For each study, include the following in the report: (1) Description of your department's clinical protocol: (a) clinical indications for study (b) precautions and contra-indications (c) patient preparation (2) Choice of method to achieve myocardial stress: (a) Physical exercise (b) Pharmacologic stress (discuss available agents) (3) Choice of radiopharmaceutical: (a) ^{201}Tl vs. ^{99m}Tc agents for Myocardial SPECT (b) in-vivo vs. modified in-vivo vs. in-vitro blood labelling for GBPS

	(c) DTPA vs. MAG3 for renal studies (d) uptake/clearance/radiation dosimetry of radiopharmaceutical (4) Study validation assessment: (a) has the study been validated in the clinical setting? (b) describe the gold standard used for validation (c) what was the outcome of the validation – include relevant sensitivity/specificity, correlation coefficient, ROC analysis (d) discuss limitations of the validation (5) Analyse the acquired study and comment on: (a) frequency filter used for Gated Cardiac SPECT (b) 8 frames vs. 16 frames vs. 32 frames for GBPS (c) automated vs. semi-automatic vs. manual ROI's for LVEF and renal function evaluation (6) Patient Management outcome: (a) comment on clinical relevance of the study (b) consequences of an inaccurate result
Knowledge Sources	**Essential** [1] SOCIETY OF NUCLEAR MEDICINE, Procedure Guidelines, http://www.snm.org/policy/new_guidelines_1.html. [2] Procedure Manual of the trainee's department [3] Supplier's reference and clinical manuals **References** [1] ELL, P., GAMBHIR, S., (Eds), Nuclear Medicine in Clinical Diagnosis and Treatment, 3rd edn., Vol. Section 8, chapter 131, Churchill Livingstone (2004). [2] SANDLER, M.P., COLEMAN, R.E., Diagnostic Nuclear Medicine, 4th edn, Lippincott Williams and Wilkins, Philadelphia (2003). [3] National Library of Medicine Medline/Pubmed search engine. See: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=PubMed
	Module 10: Clinical Applications
	Sub-module 10.4: Principles and Physiological Basis for Common Clinical Studies.
Objective	To be able to explain the principles and physiological basis for common clinical investigations, and be able to translate this knowledge to the development of new investigations.
Prerequisites	An understanding of basic human biology, biochemistry and cell function. An understanding of basic human anatomy and some medical terminology. The ability to identify the main organ systems of the body, and the major bones. If the trainee has no formal education in the above areas, undertaking a

	suitable university course is recommended. Alternatively, most medical libraries have good introductory texts covering these areas. The IAEA Distance Assisted Training Programme has a module on "Introductory Human Biology", which includes a workbook.
Competency Addressed	To understand the physiology of the principal organ systems of the body, and how nuclear medicine can be used to elucidate information about the function of these organ systems.
Core Knowledge	• Basic human biology, biochemistry and cell function. • The impact of disease and altered physiology on quantitative parameters measured using nuclear medicine techniques. • The physiological basis for investigations performed in the area they have chosen, as well as being aware of factors affecting study quality and accuracy. • Drug use for the enhancement and blocking of uptake in certain imaging protocols. • The common reasons for patients to be referred for the clinical investigations.
Recommended Elements of Training	(1) Review all the main areas of clinical application at your institution. Aim to develop an overview of the knowledge you would be expected to have to understand the clinical investigations and to meet the above competency specifications. This is an opportune time to seek physician input into development of your training requirements. (2) From this review, prepare a syllabus for yourself on physiology and disease as it relates to nuclear medicine. Focus on both traditionally strong areas of nuclear medicine (e.g. cardiac scanning), but include knowledge that may reflect trends you see in the development of nuclear medicine (topical issues). (3) From the review, and with your syllabus in mind, choose one area of clinical investigation which you would like to further explore. This should be a topical area and preferably one in which your department is involved. (4) Discuss your syllabus related to your chosen area with your advisor. You need to agree on the content of the syllabus and whether the syllabus will cover the area in sufficient detail. From the resources discussed above and the resources available within your department, prepare a directed reading programme for the area you have chosen. (5) For the chosen clinical area, prepare a portfolio of 5 case studies. Try to choose case studies that reflect different aspects of physiology and dysfunction, along with any quantitative assessment that was performed. (6) For each study, detail the indication for the procedure; the imaging procedure performed (including the basis for the chosen radiopharmaceutical and its biological behaviour); methods of analysis and normal ranges for quantitative parameters; and the likely

	physiological basis for any abnormal function. Remember, this is a training exercise. Choose challenging cases that will help teach you varying aspects of your personal syllabus. If possible, arrange to attend reporting sessions with the nuclear medicine physician/radiologist. These can be an important opportunity to gain further knowledge relating to the clinical utilisation of nuclear medicine results, and to test your understanding of the clinical procedures and quantitative measures.
Knowledge Sources	[1] DISTANT ASSISTED TRAINING PROGRAMME, Distance assisted training for nuclear medicine technologists. Module 1 Unit 3A, www.datnm.org. [2] ELGAZZAR, A.H., The Pathophysiologic Basis of Nuclear Medicine, 2nd edn, Springer, Berlin (2006). The IAEA Distance Assisted Training Programme has a module on "Introductory Human Biology", which includes a workbook. It is recommended that trainees consider undertaking a university course on general physiology. **Journals** Introductory sections to journal articles often contain a concise introduction to clinical investigations. These are worth reviewing for the area you choose as your main topic. 'The Journal of Nuclear Medicine' and 'Journal of Nuclear Medicine Technology' both publish good review articles. Some of these are available free from their website. You can access these via http://www.snm.org **Internet** The Internet contains a variety of resources for understanding pathophysiology. For example, look at http://freebooks4doctors.com and the 'Merck Manual of Diagnosis and Therapy' http://www.merck.com/mmpe/index.html .
	Module 10: Clinical Applications
	Sub-module 10.5: Developing Clinical Protocols for the Estimation of Patient Dosimetry
Objective	To be able to develop and validate a protocol for the estimation of the radiation absorbed dose to the critical organs following administration of a new diagnostic radiopharmaceutical.

<table>
<tr><td>Prerequisite</td><td>Module 6.2 Familiar with the principles of activity quantitation using planar and tomographic imaging and with the MIRD system of internal dosimetry.

Mention that a program is required to complete this module</td></tr>
<tr><td>Competency Addressed</td><td>The ability to estimate the patient dose associated with a new nuclear medicine investigation.</td></tr>
<tr><td>Core Knowledge</td><td>• The ability to select the appropriate imaging methods and sampling times to adequately measure the cumulative activity for organs and for any excreta to determine the biodistribution and radiation dosimetry for a new radiopharmaceutical
• The ability to select and use the appropriate data analysis methods
• The ability to use the MIRD method to calculate the organ doses and the effective dose.
• To understand the limitations of the MIRD method of internal dosimetry.</td></tr>
<tr><td>Recommended Elements of Training</td><td>• Read, and be reasonably familiar with, the essential resource material recommended for this competency (trainee may be orally examined on aspects of this at a later stage).
• Undertake the following tasks:
Use the data below, obtained using 99mTc-XYZ in rats, to design the acquisition protocols for a Phase 1 dosimetry study in humans for this new agent. This should include an attenuation correction method. Prepare detailed worksheets for the staff performing the studies.

^{99m}Tc-XYZ was injected intravenously into female rats and groups of animals were sacrificed at the following times: 10 mins, 30 min, 1, 2, 4, 8, 16, 24 hours. Total urinary activity was determined at the same times. The results obtained were corrected for physical decay and, when extrapolated to man, are given below as percent of administered dose.

<table>
<tr><td></td><td>10 min</td><td>30 min</td><td>1 hr</td><td>2 hr</td><td>4 hr</td><td>8 hr</td><td>16 hr</td><td>24 hr</td></tr>
<tr><td>Blood</td><td>40</td><td>15</td><td>7</td><td>3</td><td>2</td><td>1</td><td>0.5</td><td>0.25</td></tr>
<tr><td>Liver</td><td>6</td><td>4</td><td>3</td><td>3</td><td>2</td><td>2</td><td>1</td><td>0.5</td></tr>
<tr><td>Lung</td><td>2</td><td>1.8</td><td>1.5</td><td>1.0</td><td>0.8</td><td>0.6</td><td>0.4</td><td>0.2</td></tr>
<tr><td>Kidneys</td><td>5</td><td>4</td><td>4</td><td>3</td><td>3.5</td><td>2.5</td><td>2</td><td>1</td></tr>
<tr><td>Bone</td><td>7</td><td>18</td><td>25</td><td>30</td><td>32</td><td>31</td><td>33</td><td>35</td></tr>
</table>
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</table>

S Bowel	0.5	0.8	1.2	1.5	0.8	0.5	0.3	0.1
L Bowel	0.4	0.3	0.4	0.6	1.5	2.5	2.3	3.5
Urinary excreta	4	20	28	32	35	40	45	48
Remainder of the body	35.1	36.1	29.9	25.9	22.4	19.9	15.5	11.5

Undertake physical phantom experiments with an anthropomorphic phantom to determine the possible errors in the activity quantitation and determine how these would impact on the absorbed dose estimates. This should include activity estimation separately from planar and from tomographic studies. The assessment of errors should include a consideration of CT/SPECT registration errors and 3D volume definition errors.

Knowledge Sources

Essential

[1] FOOD & DRUG ADMINISTRATION, FDA Guidance for Industry: Medical Imaging Drug and Biological Products, Part 1: Conducting Safety Assessments, (2004).

[2] SIEGEL, J.A., et al., MIRD pamphlet no. 16: Techniques for quantitative radiopharmaceutical biodistribution data acquisition and analysis for use in human radiation dose estimates, J Nucl Med **40** 2 (1999) 37S-61S.

[3] STABIN, M.G., MIRDOSE: personal computer software for internal dose assessment in nuclear medicine, J Nucl Med **37** 3 (1996) 538-46.

[4] STABIN, M.G., SIEGEL, J.A., Physical models and dose factors for use in internal dose assessment, Health Phys **85** (2003) 294-310.

[5] MIRDOSE 3.1 or OLINDA/EXM

Reference

[1] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Absorbed-dose specification in Nuclear Medicine, ICRU Rep. 67, Bethesda, MD (2002).

Module 10: Clinical Applications

Sub-module 10.6: Optimization

Objective	To understand the principles of optimization in nuclear medicine procedures
Prerequisite	None

Competency Addressed	An understanding of the procedures used for risk/benefit evaluation of diagnostic and therapeutic nuclear medicine procedures. To be able to evaluate (a) diagnostic nuclear medicine procedures and diagnostic information with respect to absorbed dose to the patient. (b) radionuclide therapy procedures with respect to possibility of cure and risk for complications
Core Knowledge	• Assessment of trade-off between absorbed dose to the patient and diagnostic information in diagnostic nuclear medicine procedures • Assessment of trade-off between probability of cure and risk for complications in radionuclide therapy • The definition and appropriate use of diagnostic reference levels (DRLs). • How DRLs affect practices in the clinical setting.
Recommended Elements of Training	• Read and be reasonably familiar with the source materials relating to DRLs in nuclear medicine. • Understand why reducing the administered dose can affect image quality. • Review examination procedures and discuss whether decreased administered dose could still result in adequate image quality or if an increase in administered dose should be recommended. • Identify some reference sources for DRLs for common nuclear medicine procedures. • Develop an understanding of how the DRL is intended to guide selection of the amount of radioactivity to administered for a given diagnostic nuclear medicine procedure, and circumstances in which it might be appropriate to exceed the recommended DRL. • Develop an understanding of when it is appropriate to employ a dose reduction technique, such as the use of alternative investigations, increasing fluid intake, reducing dose and increasing scanning time, and use of thyroid blocking agents. • Be familiar with special considerations for children and young people. • Review an radionuclide therapy procedure and discuss the probability of cure and risk for complications
Knowledge Sources	[1] ADMINISTRATION OF RADIOACTIVE SUBSTANCES ADVISORY COMMITTEE, Notes for Guidance on the Clinical Administration of Radiopharmaceuticals and Use of Sealed Radioactive Sources, (2006), http://www.arsac.org.uk/notes_for_guidance/index.htm. [2] DIAZ, M.P., APARICIO, E.E., RIZO, O.D., DIAZ, R.R., RODRIGUEZ, C.H., Administered activity optimization in 99mTc-MAG3 renography for adults, J Nucl Med Technol **31** 4 (2003) 216-21.

	[3] EUROPEAN COMMISSION, Radiation Protection 109, Guidance on Diagnostic Reference Levels (DRLs) for Medical Exposures (1999). [4] HEIKKINEN, J., AHONEN, A., KUIKKA, J.T., RAUTIO, P., Quality of myocardial perfusion single-photon emission tomography imaging: multicentre evaluation with a cardiac phantom, Eur J Nucl Med **26** 10 (1999) 1289-97. [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Applying Radiation Safety Standards in Nuclear Medicine, Safety Reports Series No. 40, STI/PUB/1207, IAEA, Vienna (2005). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1207_web.pdf. [6] MATTSSON, S., JACOBSSON, L., VESTERGREN, E., The basic principles in assessment and selection of reference doses: considerations in nuclear medicine, Rad Prot Dosim **80** 1 (1998) 23-27. [7] MOONEN, M., JACOBSSON, L., Effect of administered activity on precision in the assessment of renal function using gamma camera renography, Nucl Med Commun **18** 4 (1997) 346-51.
	Module 10: Clinical Applications
	Sub-module 10.7: The Physiological Basis of PET Imaging
Objective	To gain an understanding of the principles and physiological basis for common clinical PET and PET/CT studies.
Prerequisite	Understand the principles of PET/CT, including instrumentation, FDG production and image acquisition/reconstruction.
Competency Addressed	To understand the principles and physiological basis for common clinical PET and PET/CT studies. The ability to recognise the normal appearances for brain, heart and whole body studies as well as common abnormal appearances and artefacts.
Core Knowledge	o Mechanisms of uptake of FDG into normal tissues and tumours. o Main assumptions of the SUV method and explain its relationship to the autoradiographic FDG method. o Clinical protocols for FDG brain, heart and whole body imaging for cancer. o Role of and typical parameters for CT in PET/CT clinical studies. o radiation safety and patient dosimetry for PET/CT studies
Recommended Elements of Training	• Document the mechanisms of uptake of FDG into normal tissues and tumours and clearance from the blood, making note of the different mechanisms in brain, heart and other major organs. Also discuss how these mechanisms are affected by serum glucose levels, anxiety and other factors. • Write down the equation for the autoradiographic FDG method and, by making simplifying assumptions, show how it can lead to the equation

	that describes the SUV method. List the main assumptions and discuss their validity. • Document each of the common clinical PET protocols, including the use of CT when available (and discuss its clinical usefulness). Also discuss radiation safety issues and patient dosimetry relevant to clinical PET/CT. • Discuss in detail the normal and common abnormal appearances (including artefacts) for one of the above clinical protocols, using clinical examples to illustrate the main points. • The trainee should spend at least 2 weeks in a department with clinical PET.
Knowledge Sources	[1] BAILEY, D.L., TOWNSEND, D.W., VALK, P.E., MAISEY, M.N., (Eds), Positron Emission Tomography: Basic Sciences, Springer-Verlag, London, (2005). [2] SEMMLER, W., SCHWAIGER, M., (Eds), Molecular Imaging 1, Handbook of Experimental Pharmacology, Springer-Verlag, Berlin, (2008). [3] THIE, J.A., Understanding the standardized uptake value, its methods, and implications for usage, J Nucl Med **45** 9 (2004) 1431-4. [4] Review articles in Nuclear Medicine journals

	MODULE 11 – PREPARATION AND QUALITY CONTROL OF RADIOPHARMACEUTICALS
Objective	To become familiar with the quality control test associated with radiopharmaceuticals preparation.
Expected Duration	5% of overall time.
Sub-Modules	(1) The production and preparation of radiopharmaceuticals (2) Quality control of the radiopharmaceuticals
Core Reading	[1] EARLY, P.J., SODEE, D.B., Principles and Practice of Nuclear Medicine, 2nd edn, Mosby (1994). [2] SAHA, G.B., Physics and Radiobiology of Nuclear Medicine, 3rd edn, Springer Verlag (2006).
	Module 11 – Preparation and Quality Control of Radiopharmaceuticals
	Sub-module 11.1-The Production and Preparation of Radiopharmaceuticals
Objective	To understand the principles of radiopharmaceutical production and preparation for clinical nuclear medicine imaging.
Prerequisites	Sub-module 2.1 Monitoring radiation levels including personnel monitoring Sub-module 2.2 Exposure from sealed and unsealed sources and the risk of contamination Sub-module 2.5 Areas designated for the use of unsealed radioactive material
Competencies Addressed	Familiarity with the facilities necessary for the production of radionuclides and radiopharmaceuticals. Ability to apply appropriate protocols to prepare Tc-99m-labelled radiopharmaceuticals.
Core Knowledge	• Principles of radionuclide productions • The protocol for radiopharmaceutical preparations
Recommended Elements of Training	• Study the methods for radionuclide production including o Nuclear reactor and cyclotron o Production of radionuclide o Chemistry of Technetium

	• Observe the procedures for the preparation of radiopharmaceuticals including o Radionuclide generator o Laboratory technique o Preparation of radiopharmaceuticals • Perform radionuclide measurement o Total activity of the eluate using a radionuclide calibrator o Calculate the activity concentration • Study the radionuclide and radiopharmaceuticals requirements for clinical imaging o Tc-99m –MDP for bone imaging o Tc-99m –DTPA, DMSA and MAG-3for kidney imaging o Tc-99m – DISIDA for hepato-biliary imaging o Tc-99m-Sn-RBC for cardiac imaging and function studies. o Etc.
Knowledge Sources	[1] DISTANT ASSISTED TRAINING PROGRAMME, Distance assisted training for nuclear medicine technologists. Module 1 Unit 3A, www.datnm.org. [2] EMERALD CONSORTIUM, European Medical Radiation Learning Development (EMERALD), Student Training Workbook, Module 2, Physics of Nuclear Medicine, (2001), http://emitdictionary.co.uk/Emerald2/emit/Emerald2/nm_mod/workbook/nm_cover2.pdf. [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparation of Kits for 99Tcm Radiopharmaceuticals, IAEA-TECDOC-649, IAEA, Vienna (1992). http://www-pub.iaea.org/MTCD/publications/PDF/te_649_web.pdf. [4] INTERNATIONAL ATOMIC ENERGY AGENCY, Production of 99Tcm Radiopharmaceuticals for Brain, Heart and Kidney Imaging, IAEA-TECDOC-805, IAEA, Vienna (1995). http://www-pub.iaea.org/MTCD/publications/PDF/te_805_web.pdf. [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Medicine Resources Manual, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1198_web.pdf. [6] MILLAR, A.M., "Documentation, labelling, packaging and transportation", Textbook of radio pharmacy: theory and practice, (SAMPSON, C.B., Ed.), Gordon and Breach, New York, (1999) 195–204. [7] THEOBALD, A.E., "Quality control of radiopharmaceuticals", Textbook of radiopharmacy: theory and practice, (SAMPSON, C.B., Ed.), Gordon and Breach, New York, (1999) 145–185.

	Module 11 – Preparation and Quality Control of Radiopharmaceuticals
	Sub-module 11.2 - Quality Control of the Radiopharmaceuticals
Objective	To understand the quality control in the radiopharmaceuticals.
Prerequisites	Sub-module 11.1: The production and preparation of radiopharmaceuticals
Competencies Addressed	An understanding of quality control procedures and their importance for radiopharmaceuticals. Be able to perform basic QC tests of radiopharmaceuticals.
Core Knowledge	• Principles of quality control and the importance of the test for the quality of the examinations. • Understanding of the Quality Control tests including : o Physical characteristics o Radionuclide purity o Radiochemical purity o Chemical purity • Procedures of an aseptic practice in daily radiopharmaceuticals preparations o Biological quality control o Mechanism of radiopharmaceutical purity.
Recommended Elements of Training	• Study the principles of quality control of radiopharmaceuticals • Review the documentation and results of quality control procedures, suggest further action • Observe the QC procedures including biological quality control – o Sterility o Pyrogen test • Perform the QC of the radiopharmaceuticals including o Chemical purity using chromatographic methods o Classify the impurities o ITLC-SG(Instant thin layer chromatography-silica gel) preparation o Calculation the percentage activity the free pertechnetate and reduced hydrolyzed o Typical results with pass criteria o Determine the molybdenum break through using the lead pot method and alumina contamination using the spot test procedure • Describe the relevance of each QC for the quality of the examination and safety of the patients.

Knowledge Sources	[1] DISTANT ASSISTED TRAINING PROGRAMME, Distance assisted training for nuclear medicine technologists. Module 1 Unit 3A, www.datnm.org. [2] EMERALD CONSORTIUM, European Medical Radiation Learning Development (EMERALD), Student Training Workbook, Module 2, Physics of Nuclear Medicine, (2001), http://emitdictionary.co.uk/Emerald2/emit/Emerald2/nm_mod/workbook/nm_cover2.pdf. [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparation of Kits for 99Tcm Radiopharmaceuticals, IAEA-TECDOC-649, IAEA, Vienna (1992). http://www-pub.iaea.org/MTCD/publications/PDF/te_649_web.pdf. [4] INTERNATIONAL ATOMIC ENERGY AGENCY, Production of 99Tcm Radiopharmaceuticals for Brain, Heart and Kidney Imaging, IAEA-TECDOC-805, IAEA, Vienna (1995). http://www-pub.iaea.org/MTCD/publications/PDF/te_805_web.pdf. [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Medicine Resources Manual, IAEA, Vienna (2006). http://www-pub.iaea.org/MTCD/publications/PDF/Pub1198_web.pdf. [6] MILLAR, A.M., "Documentation, labelling, packaging and transportation", Textbook of radiopharmacy: theory and practice, (SAMPSON, C.B., Ed.), Gordon and Breach, New York, (1999) 195–204. [7] THEOBALD, A.E., "Quality control of radiopharmaceuticals", Textbook of radiopharmacy: theory and practice, (SAMPSON, C.B., Ed.), Gordon and Breach, New York, (1999) 145–185.

APPENDIX V

COMPETENCY ASSESSMENT

COMPETENCY ASSESSMENT OF RESIDENTS ENROLLED IN THE CLINICAL TRAINING PROGRAM FOR NUCLEAR MEDICINE PHYSICISTS

Resident's name: _____

Clinical Supervisor's name: _____

(Note: Refer to the Appendix IV *Clinical Training Guide* for recommended elements of training in each sub-module)

EXPLANATION OF THE ASSESSMENT PROCESS

The assessment process involves assessment of both knowledge and practical competencies associated with sub modules. Where there is more than one knowledge or one practical competency per sub module, the competency is labelled a, b, etc., so for example sub module 5.10 has two knowledge competencies, a & b, and two practical competencies, a & b.

For assessment of a Resident's knowledge there are two levels to consider. Assessment at level 2 indicates a basic understanding of the core knowledge and level 1 is the level of knowledge expected of a practicing Nuclear Medicine Physicist.

For assessment of practical competencies there are 3 levels to be considered. The levels have descriptive indicators to assist in maintaining a consistent approach to assessment of competency. The descriptive indicator for a level needs to be considered in relation to the indicator for lower levels of competency. For example, when considering assessment at level 1 also ensure that the Resident has demonstrated the levels of competency indicated by levels 3 and 2.

A Resident may progress more than one level at the time of an assessment. Likewise they might in the first assessment of their competency in a particular sub-module be assessed at any level. It is also possible that they might regress from one assessment to the next. i.e. be assessed at level 2 and then at a later date at level 3. A hypothetical assessment of a sub-module is provided below.

As demonstrated by the criteria, competency assessment is not just reviewing technical ability but also professional attributes, such as safe practice and communication skills, expected of a qualified medical physicist specialising in nuclear medicine physics.

IMPORTANT NOTES:

This document should be retained by the Resident for the duration of his/her clinical training programme. It may be reviewed by the National Programme Coordinator or other responsible person at any time. It must also be made available to the National Programme Coordinator just prior to the final oral examination.

It is recommended that a copy is made of this document at regular intervals and that this copy is retained by the Clinical Supervisor. In the event that the Resident loses their copy then the Clinical Supervisor's copy provides a reasonably up to date record of competency assessment.

ASSESSMENT CRITERIA

The assessment process has two principal objectives:

(1) To determine whether the resident has the knowledge, experience and skills to satisfactorily complete aspects of nuclear medicine physics work that are commonly encountered in clinical practice.

(2) To satisfy the relevant professional body and/or the National Responsible Authority11 that the resident can work competently and safely as a clinically qualified nuclear medicine physicist.

This requires an assessment of the abilities that the resident exhibits during training as evidenced by the processes described in this document. In this assessment process the criteria used include the following competency indicators:

(1) A careful, logical and thorough approach to work undertaken;

(2) Self-confidence together with recognition of the limitations of one's knowledge and expertise;

(3) A broad understanding of tasks or topics;

(4) Adequate theoretical knowledge relating to nuclear medicine physics;

(5) Ability to identify and define a problem then formulate strategies to address the problem;

(6) Practical skills in carrying out tasks and completing them in a timely manner;

(7) A clear understanding of the various procedures involved in carrying out tasks undertaken during their training and in their examinations;

(8) Knowledge of relevant standards and in most cases the type of results to be expected in relation to the tasks undertaken;

(9) Ability to correctly interpret data, including novel or non-standard data;

(10) An appreciation of the significance of results obtained in a task and their applicability within a nuclear medicine department;

(11) Ability to critically evaluate processes and outcomes, and make value judgements for particular situations;

(12) Ability to communicate scientific information clearly, logically and accurately, including explaining work as it is undertaken;

(13) Taking responsibility for work undertaken.

[11] See Appendix III.1.1.

AN EXAMPLE OF THE ASSESSMENT MATRIX OF A SUB-MODULE

Sub module 5.1: Acquisition and Life Cycle of Nuclear Medicine Equipment

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
To understand the procedures for acceptance testing and equipment maintenance as well as verification of equipment performance after maintenance.	Demonstrates a **basic understanding** of the generic elements of the life cycle of nuclear medicine equipment **including** planning, purchase, acceptance and commissioning, maintenance and verification of equipment performance after maintenance.	Demonstrates a **good understanding** of the elements of the life cycle of nuclear medicine equipment.
Date Achieved	3 March 2010	6 June 2010
Supervisor's Initials	*MeL*	*MeL*

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The capability to make budgetary requests, prepare specifications and acquire suitable equipment through a tendering process	Is capable of **contributing** to the **development** of budgetary requests, preparing specifications and acquiring equipment through a tendering process. **Requires assistance** with the concepts involved.	Is capable of **providing the "physics" input** to budgetary requests, preparation of specifications and acquisition of equipment through a tendering process. **Requires only minimal assistance** to ensure all necessary elements are included. **Any omissions are minor.**	Is capable of **independently providing the "physics" input** to budgetary requests, preparation of specifications and acquisition of equipment through a tendering process.
Date Achieved	6 June 2010		19 Dec 2010
Supervisor's Initials	*MeL*		*MeL*

Date	**Supervisor's comments**
3 March 2010	Needs to learn more detail of the principles involved.
6 June 2010	Has made good progress in acquiring this competency.
19 Dec 2010	This Resident is capable of providing this departments input to a tender process.

ASSESSMENT SUMMARY

MODULE 1: CLINICAL AWARENESS

	Level of Competency Achieved (Date)				
	Knowledge		Practical skills		
	2	1	3	2	1
1.1 Essential anatomy and physiology for the nuclear medicine physicist	a) b)				
1.2 Basic principles of radiation biology and epidemiology					
1.3 Clinical activities and factors that affect patient care ° Nuclear medicine ° Radiology ° Radiation oncology ° Other areas					

MODULE 2: RADIATION PROTECTION

	Level of Competency Achieved (Date)				
	Knowledge		Practical skills		
	2	1	3	2	1
(2.1) Monitoring radiation levels including personnel monitoring.	(a) (b)				
(2.2) Exposure from sealed and unsealed sources and the risk of contamination.			a) b)		
(2.3) ALARA and radiation safety precautions in nuclear medicine diagnostic and therapeutic procedures.					
(2.4) Risk assessment and advice to staff, patients and others regarding radiation risk.	(a) (b) (c)				

(2.5) Areas designated for the use of unsealed radioactive material.	(a) (b)					
(2.6) Radiation shielding considerations in the design of new facilities.	(a) (b)					
(2.7) Regulatory controls and other guidance on the safe use of ionising radiation in nuclear medicine.						

MODULE 3: RESEARCH, DEVELOPMENT AND TEACHING

	Level of Competency Achieved (Date)					
	Knowledge			**Practical skills**		
	2	**1**		**3**	**2**	**1**
3.1 Research and development.						
3.2 Teaching.						

MODULE 4: PROFESSIONAL DEVELOPMENT

	Level of Competency Achieved (Date)					
	Knowledge			**Practical skills**		
	2	**1**		**3**	**2**	**1**
4.1 Professional awareness.						
4.2 Communication.						
4.3 Quality management.						
4.4 Clinical audit.						

MODULE 5: EQUIPMENT PROCUREMENT, ACCEPTANCE TESTING AND COMMISSIONING

	Level of Competency Achieved (Date)				
	Knowledge			Practical skills	
	2	1	3	2	1
5.1 Equipment acquisition and life cycle of nuclear medicine equipment.					
5.2 Dose calibrator acceptance testing.					
5.3 Scintillation probe and well counter acceptance testing.					
5.4 Gamma camera, SPECT/ CT acceptance and commissioning.					
5.5 PET/CT acceptance and commissioning.			(a) (b)		

MODULE 6: RADIOACTIVITY MEASUREMENTS AND INTERNAL DOSIMETRY

	Level of Competency Achieved (Date)				
	Knowledge			Practical skills	
	2	1	3	2	1
6.1 Use of traceable standards for radioactivity measurements.					
6.2 Formalism and application of internal dosimetry.					
6.3 Radiation dose from diagnostic nuclear medicine radiopharmaceuticals.					
6.4 Quantitative nuclear medicine imaging.					
6.5 Patient-specific dosimetry.					

MODULE 7: QUALITY CONTROL OF NUCLEAR MEDICINE EQUIPMENT

	Level of Competency Achieved (Date)				
	Knowledge			Practical skills	
	2	1	3	2	1
7.1 Design and supervision of a routine QC program.					
7.2 QC of a dose calibrator.					
7.3 QC of a scintillation probe and well counter.					
7.4 QC of gamma camera and SPECT.			(a) (b)		
7.5 QC of PET/CT systems.					
7.6 QC of display and hardcopy devices.	(a) (b)				
7.7 QC of DXA systems.					

MODULE 8: RADIONUCLIDE THERAPY USING UNSEALED SOURCES

	Level of Competency Achieved (Date)				
	Knowledge			Practical skills	
	2	1	3	2	1
8.1 Principles of radionuclide therapy.					
8.2 Facility design for radionuclide therapy.					
8.3 Treatment procedures.					
8.4 Selection of radiopharmaceuticals for nuclear medicine therapy.	(a) (b)				
8.5 Dosimetry for radionuclide therapeutic procedures.					

8.6 Radiation safety precautions for therapy using unsealed radionuclide sources.	(a) (b)			(a) (b)		

MODULE 9 – CLINICAL COMPUTING AND NETWORKING

	Level of Competency Achieved (Date)					
	Knowledge			**Practical skills**		
	2	**1**		**3**	**2**	**1**
9.1 Operation of a clinical acquisition and processing/reviewing workstation.						
9.2 Computer system administration management.						
9.3 First line computer system troubleshooting.				(a) (b)		
9.4 Computer image processing techniques.						
9.5 Image analysis in a high level programming language (optional).						
9.6 Image reconstruction, registration and fusion, and tracer kinetic modelling.				(a) (b)		
9.7 Standard image file formats used in nuclear medicine.						
9.8 Computer networking, PACS, RIS and HIS.				(a) (b) (c)		
9.9 Software validation: computer simulations, phantoms and clinical data.				(a) (b)		

MODULE 10: CLINICAL APPLICATIONS

	Level of Competency Achieved (Date)					
	Knowledge			Practical skills		
	2	1		3	2	1
10.1 Protocols for routine clinical procedures.						
10.2 Common artefacts in clinical images.						
10.3 Analysis of common clinical studies and sources of error.						
10.4 Principles and physiological basis for common clinical studies.						
10.5 Developing clinical protocols for the estimation of patient dosimetry.						
10.6 Optimization.				(a) (b)		
10.7 The physiological basis of PET imaging.						

MODULE 11: PREPARATION AND QUALITY CONTROL OF RADIOPHARMACEUTICALS

	Level of Competency Achieved (Date)					
	Knowledge			Practical skills		
	2	1		3	2	1
11.1 Production and preparation of radiopharmaceuticals						
11.2 Quality control of the radiopharmaceuticals						

MODULE 1: CLINICAL AWARENESS

1.1 Essential anatomy and physiology for the nuclear medicine physicist
1.2 Basic principles of radiation biology and epidemiology
1.3 Clinical activities and factors that affect patient care

Sub-module 1.1: Essential Anatomy and Physiology for the Nuclear Medicine Physicist

Knowledge Base (a)	**Level of Competency Achieved**	
	2	**1**
An understanding of anatomy and physiology as seen on nuclear medicine images and in dynamic studies.	Demonstrates **a basic understanding** of anatomy and physiology as seen on static and dynamic nuclear medicine images.	Demonstrates **a good understanding** of anatomy and physiology as seen on static and dynamic nuclear medicine images.
Date Achieved		
Supervisor Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
Basic knowledge of anatomy and physiology as seen on other types of medical images.	Demonstrates **a basic understanding** of anatomy and physiology as seen on **two** of the following types of medical images:- **radiographs, CT, MRI, US**	Demonstrates **a basic understanding** of anatomy and physiology as seen on the following types of medical images:- **radiographs, CT, MRI, US**
Date Achieved		
Supervisor Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to discuss with nuclear medicine specialist the important features of diagnostic images	Has only a **limited ability** to discuss the important features of diagnostic NM images with medical specialists.	**A good knowledge of** the important features of diagnostic NM images. However n**ot yet capable of independent input** to a discussion with medical specialists.	Is capable of **independently discussing** the important features of diagnostic NM images with medical specialists.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor comments**

Sub-module 1.2: Basic Principles of Radiation Biology and Epidemiology

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the basic principles of radiation biology and epidemiology	Demonstrates a **basic understanding** of **most** aspects of radiation biology and epidemiology of **relevance to nuclear medicine imaging.**	Demonstrates a **good understanding** of **all** of radiation biology and epidemiology of **relevance to nuclear medicine imaging.**
Date Achieved		
Supervisor Initials		

Date	**Supervisor comments**

Sub-module 1.3: Clinical Activities and Factors that Affect Patient Care.

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the factors that affect patient care	Demonstrates a **basic understanding** of clinical activities and their relation to patient care.	Demonstrates a **good understanding** of clinical activities and their relation to patient care.
Date Achieved		
Supervisor Initials		

Practical Skills	**Level of Competency Achieved**	
	2	**1**
An ability to discuss clinical activities and their relation to patient care in the following areas.	**Demonstrates a limited ability** to contribute to a discussion of the important features of clinical activities and their relation to patient care.	**Is capable of independent and well informed input** to a discussion of the important features of clinical activities and their relation to patient care.
Date Achieved - Nuclear Medicine		
Supervisor Initials		
Date Achieved – Radiology		
Supervisor Initials		
Date Achieved – Radiation Oncology		
Supervisor Initials		
Date Achieved – Other Areas		
Supervisor Initials		

Date	Supervisor comments

MODULE 2: RADIATION PROTECTION

2.1 Monitoring radiation levels including personnel monitoring
2.2 Exposure from sealed and unsealed sources and the risk of contamination
2.3 ALARA and radiation safety precautions in nuclear medicine diagnostic and therapeutic procedures
2.4 Risk assessment and advice to staff, patients and others regarding radiation risk
2.5 Areas designated for the use of unsealed radioactive material
2.6 Radiation shielding considerations in the design of new facilities
2.7 Regulatory controls and other guidance on the safe use of ionising radiation in nuclear medicine

Sub-module 2.1: Monitoring Radiation Levels Including Personnel Monitoring

Knowledge Base (a)	**Level of Competency Achieved**	
	2	**1**
An understanding of the principles of operation of equipment used for monitoring radiation levels in nuclear medicine.	Demonstrates a **basic understanding** of the **principles of operation** and **limitations** of a **variety of the equipment** used for monitoring radiation levels**.**	Demonstrates a **good understanding** of the principles of operation and limitations of **equipment** used for monitoring radiation levels
Date Achieved		
Supervisor's Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
An understanding of the purpose, principles and operation of a personnel dosimetry program.	Demonstrates a **basic understanding** of **principles of operation** and **limitations of a variety of personnel dosimeters**	Demonstrates a **good understanding** of the principles of operation, and limitations of **most personnel dosimeters of relevance to nuclear medicine.**
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to measure radiation levels and to perform quantitative measurement of contamination.	Is capable of measuring radiation levels **and** performing quantitative measurement of contamination**. Requires supervision.**	Is capable of measuring radiation levels and performing quantitative measurement of contamination**. Requires only limited assistance.**	Is capable of measuring radiation levels and **independently** performing quantitative measurement of contamination.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 2.2: Exposure from Sealed and Unsealed Sources and the Risk of Contamination

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of methods to reduce exposure.	Possesses a **basic** understanding of the methods used to reduce exposure.	Possesses a **good** understanding of the methods used to reduce exposure.
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to safely handle unsealed radioactive sources.	**Requires close supervision** when handling unsealed radioactive sources to ensure safe practice**.**	Requires **only limited supervision** when handling unsealed radioactive sources to ensure safe practice**.**	Is capable of safely handling unsealed radioactive sources.
Date Achieved			
Supervisor's Initials			
Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to handle accidents and spills.	Is capable of **assisting with the response** related to accidents and spills. **Requires close supervision.**	Requires only limited assistance in responding to accidents and spills. **Requires only loose supervision.**	Is capable of **independently responding** to accidents and spills.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 2.3: ALARA and Radiation Safety Precautions in Nuclear Medicine Diagnostic and Therapeutic Procedures.

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the application of the ALARA principle	Demonstrates a **basic understanding** of the need to keep **doses as low as reasonably achievable** and to **ensure regulatory compliance.**	Demonstrates a **good understanding** of the need to keep doses as low as reasonably achievable and to ensure regulatory compliance.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to apply radiation protection regulations in clinical nuclear medicine practice.	Is capable of applying radiation protection regulations **under supervision. Needs assistance** to identify and implement remedial measures	Is capable of applying radiation protection regulations **with only limited supervision.** Able to identify and implement **most** remedial measures	Is capable of **independently** applying radiation protection regulations and is able to **independently** identify and implement remedial measures.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 2.4: Risk Assessment and Advice to Staff, Patients and Others Regarding Radiation Risk

Knowledge Base (a)	**Level of Competency Achieved**	
	2	**1**
An understanding of the methods for estimating effective dose to the patient from diagnostic nuclear medicine scans.	Possesses a **basic** understanding of methods for estimating effective dose to the patient from diagnostic nuclear medicine scans.	Possesses a **good** understanding of methods for estimating effective dose to the patient from diagnostic nuclear medicine scans.
Date Achieved		
Supervisor's Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
Knowledge of the risks associated with radiation exposure.	Demonstrates a **basic** understanding of regulatory requirements and the principles of hazard assessment and control mechanisms. **Requires assistance** with understanding of the **more difficult aspects**.	Demonstrates a **good understanding** of all aspects of hazard assessment and control mechanisms and is able to instruct others.
Date Achieved		
Supervisor's Initials		
Knowledge Base (c)	**Level of Competency Achieved**	
	2	**1**
An understanding of the procedures for risk assessment.	Possesses a **basic** understanding of the procedures for risk assessment. **Requires guidance** to ensure that **all risks are identified.**	Possesses a **good** understanding of the procedures for risk assessment.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to communicate risk or lack of risk in the context of dose, justification and relevant non-radiation risks	Possesses only a **limited ability** to advise others on correct practical aspects to reduce dose and to limit non-radiation risks.	Is capable of advising others on practical aspects to reduce dose and to limit non-radiation risks. Requires **supervision** to ensure that **no incorrect advice** is provided.	Is capable of **independently advising** others on practical aspects to reduce dose and to limit non-radiation risks. **The advice provided is at all times correct and appropriate.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 2.5: Areas Designated for the Use of Unsealed Radioactive Material

Knowledge Base (a)	**Level of Competency Achieved**	
	2	**1**
Familiarity with the designation of areas of the workplace associated with protection from unsealed radioactive materials.	Has a **basic** familiarity with the designation of areas of the workplace associated with protection from unsealed radioactive materials.	Has a **good** familiarity with the designation of areas of the workplace associated with protection from unsealed radioactive materials.
Date Achieved		
Supervisor's Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
Familiarity with the different radionuclide decay processes.	Possesses a **limited** understanding of radionuclide decay processes.	Possesses a **very good** understanding of radionuclide decay processes.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to manage a radioactive waste store for the sources used in a nuclear medicine department.	Is able to **assist** with management of a radioactive waste store. **Requires supervision** to **ensure safe practice**.	Is able to manage a radioactive waste store. **Requires only limited supervision** to **ensure safe practice**.	Is able to **independently** manage a radioactive waste store applying **best practice**.
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 2.6: Radiation Shielding Considerations in the Design of New Facilities

Knowledge Base (a)	Level of Competency Achieved	
	2	1
An understanding of the principles and requirements of shielding design for radionuclide energies used for diagnostic Nuclear Medicine purposes.	Demonstrates a **basic understanding** of shielding design for radionuclide energies used in diagnostic Nuclear Medicine.	Demonstrates a **good understanding** of shielding design for radionuclide energies used in diagnostic Nuclear Medicine.
Date Achieved		
Supervisor's Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
Familiarity with shielding requirements for PET, SPECT installations in combination with other imaging (e.g. CT) modalities	Demonstrates a **basic understanding** of shielding requirements for PET, SPECT installations in combination with other imaging (e.g. CT) modalities	Demonstrates a **good understanding** of shielding requirements for PET, SPECT installations in combination with other imaging (e.g. CT) modalities
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to design satisfactory radiation shielding for all types of nuclear medicine equipment.	Is capable of **contributing** to the design of radiation shielding for **simple** nuclear medicine equipment. **Requires significant assistance** to ensure the accuracy of the design.	Is capable of designing radiation shielding for **most** nuclear medicine equipment. R**equires only limited assistance** to ensure the accuracy of the design.	Is capable of **independently designing radiation** shielding **for all** nuclear medicine equipment **to an acceptable level.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 2.7: Regulatory Controls and Other Guidance on the Safe Use of Ionising Radiation in Nuclear Medicine

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the local regulatory requirements for Nuclear Medicine.	Demonstrates a **basic understanding** of **local regulatory requirements** for Nuclear Medicine and the **principles of hazard assessment and control mechanisms. Requires assistance** with understanding of the **more difficult aspects.**	Demonstrates a **good understanding** of **local regulatory requirements** for Nuclear Medicine and all aspects of hazard assessment and control mechanisms.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to advise on local, regional and national radiation protection and safety legislation.	Possesses only a **limited ability** to advise others on local, regional and national radiation protection and safety legislation.	Is capable of advising others on local, regional and national radiation protection and safety legislation. Requires **supervision** to ensure that **no incorrect advice** is provided.	Is capable of **independently advising** others on local, regional and national protection and safety legislation. **The advice provided is at all times correct and appropriate.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

MODULE 3: RESEARCH, DEVELOPMENT AND TEACHING

3.1 Research and Development
3.2 Teaching

Sub-module 3.1: Research and Development

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of processes of scientific research including the role of ethics review, statistical analysis, and the publication process	Demonstrates a **basic understanding** of the various aspects of scientific research.	Demonstrates a **good appreciation** of the various aspects of scientific research.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to carry out research and development in nuclear medicine physics in cooperation with nuclear medicine physicians, diagnostic medical physicists, radiation oncology medical physicists and other professionals.	Is capable of **contributing** to a R&D project. **Requires significant guidance**.	Able to contribute to a R&D project **without direct supervision**.	Demonstrates a good level of ability for **independent research.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 3.2: Teaching

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the general principles of effective teaching	Demonstrates a **basic understanding** of strategies for teaching and assessment as well as development of instructional material.	Demonstrates a **good understanding** of strategies for teaching and assessment as well as development of instructional material. Pays particular attention to the **needs and background of the audience.**
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to teach principles and methods of nuclear medicine physics.	Demonstrates a **limited ability to prepare and deliver short (1-2 hour) courses. Requires guidance.**	Demonstrates a **good ability to prepare and deliver** appropriate short courses **without significant guidance.**	Demonstrates the ability to **decide on content, prepare and deliver a comprehensive course** on principles and methods of nuclear medicine physics.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

MODULE 4: PROFESSIONAL DEVELOPMENT

4.1 Professional awareness
4.2 Communication
4.3 Quality management
4.4 Clinical audit

Sub-module 4.1: Professional Awareness

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Demonstrated understanding of professional issues.	Demonstrates only a **limited awareness** of relevant professional issues.	Demonstrates a **good awareness** of **most** relevant professional issues.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Contribution to professional body activities.	**Occasionally participates** in professional body activities.	**Frequently participates** in professional body activities.	**Contributes** to professional body activities.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 4.2: Communication

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Demonstrate a high level of oral and written communication and interpretation skills.	Generally demonstrates **clear and concise** expression orally and in written forms.	**Consistently demonstrates clear and concise expression** orally and in written forms. **Capable of presenting a scientific seminar** and **preparing a scientific manuscript**.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to communicate with clinicians and apply physical principles to clinical problems	Able to communicate with clinicians at a **basic level.**	Possesses a **good ability** to communicate with clinicians **and to apply (explain)** physical principles applied to clinical problems**. Occasionally requires assistance with these explanations.**	Is capable of **independently communicating** with clinicians in **relation to the physical principles of clinical problems.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 4.3: Quality management

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Understanding of the structure of a quality system	Demonstrates a **basic understanding** of the **key elements** and **the role** of a quality management system in nuclear medicine.	Demonstrates a **good understanding** of the key elements and role of a quality management system in nuclear medicine.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to implement and maintain the physics aspects of the quality system			
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 4.4: Clinical audit

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Understand the nature, purpose of clinical audit in the Nuclear Medicine setting	Demonstrates a **limited understanding** of the nature, purpose of clinical audit including any **local legislative requirements**.	Demonstrates a **good understanding** of the nature, purpose of clinical audit including any local legislative requirements.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to effectively contribute as a member of a multidisciplinary team to a nuclear medicine department	Is capable of **contributing** to a clinical audit. **Requires significant guidance**.	Able to contribute to a clinical audit **without direct supervision**.	Able to **independently conduct** the physics aspects of a clinical audit to an acceptable level.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

MODULE 5: EQUIPMENT PROCUREMENT, ACCEPTANCE TESTING AND COMMISSIONING

5.1 Equipment acquisition and life cycle of nuclear medicine equipment
5.2 Dose calibrator acceptance testing
5.3 Scintillation probe and well counter acceptance testing
5.4 Gamma camera, SPECT/CT acceptance and commissioning
5.5 PET/CT acceptance and commissioning

Sub-module 5.1: Equipment Acquisition and Life Cycle of Nuclear Medicine Equipment

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
To understand the procedures for acceptance testing and equipment maintenance as well as verification of equipment performance after maintenance.	Demonstrates a **basic understanding** of the generic elements of the life cycle of nuclear medicine equipment **including** planning, purchase, acceptance and commissioning, maintenance and verification of equipment performance after maintenance.	Demonstrates a **good understanding** of the elements of the life cycle of nuclear medicine equipment.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The capability to make budgetary requests, prepare the specifications and acquire suitable equipment through a tendering process	Is capable of **contributing** to the **development** of budgetary requests, preparing specifications and acquiring equipment through a tendering process. **Requires assistance** with the concepts involved.	Is capable of **providing the "physics" input** to budgetary requests, preparation of specifications and acquisition of equipment through a tendering process. **Requires only minimal assistance** to ensure all necessary elements are included. **Any omissions are minor.**	Is capable of **independently providing the "physics" input** to budgetary requests, preparation of specifications and acquisition of equipment through a tendering process.
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 5.2: Dose Calibrator Acceptance Testing.

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the procedure for initial acceptance of a dose calibrator	Demonstrates a **limited understanding** of the **principles of operation** of a dose calibrator and the **recommended accepting tests**.	Demonstrates an **in-depth understanding** of the principles of operation of a dose calibrator and the recommended accepting tests.
Date Achieved		
Supervisor's Initials		

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
Ability to perform dose calibrator acceptance testing	Is capable of **contributing to acceptance testing** of a dose calibrator including physical inspection, precision and accuracy, linearity of activity response and background test. **Requires assistance** to ensure that there are no errors in the process.	Is **capable of performing acceptance testing** of a dose calibrator. Requires only **minimal assistance** Makes **occasional minor errors**.	Is capable of **independently performing acceptance testing** of a dose calibrator to **an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 5.3: Scintillation Probe and Well Counter Acceptance Testing.

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the procedure for initial acceptance testing of a scintillation probe or well counter	Demonstrates a **limited understanding** of the **principles of operation** of a scintillation probe or well counter and **the recommended acceptance tests**	Demonstrates an **in-depth understanding** of the principles of operation of a scintillation probe or well counter and the procedures for accepting testing.
Date Achieved		
Supervisor's Initials		

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
Ability to perform acceptance testing of a scintillation probe or well counter.	Is **capable of contributing to acceptance testing** of scintillation probe or well counter including physical inspection, energy calibration and resolution, sensitivity, precision and accuracy, linearity of activity response and background test. **Requires assistance** to ensure that there are no errors in the process.	Is **capable of performing acceptance testing** of a scintillation probe or well counter. Requires only **minimal assistance** Makes **occasional minor errors**.	Is capable of **independently performing acceptance testing** of a scintillation probe or well counter to **an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 5.4: Gamma Camera, SPECT and CT Acceptance and Commissioning.

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the procedure for acceptance test of gamma camera/SPECT and CT systems	Demonstrates a **limited understanding** of the standards for **acceptance testing** of **gamma camera/SPECT and CT systems** as well as **interpretation of results**.	Demonstrates a **good understanding** of the standards for **acceptance testing** of gamma camera/SPECT systems as well as **interpretation of results**.
Date Achieved		
Supervisor's Initials		

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
Ability to perform acceptance testing of gamma camera / SPECT systems.	Is **capable of contributing to acceptance testing** of gamma camera/SPECT systems. **Requires assistance** to ensure that there are no errors in the process.	Is **capable of performing acceptance testing** of gamma camera/SPECT systems. Requires only **minimal assistance** Makes **occasional minor errors**.	Is capable of **independently performing acceptance testing** of gamma camera/SPECT systems to **an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 5.5: PET/CT Acceptance and Commissioning.

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of NEMA procedures for PET acceptance testing	Demonstrates a **limited understanding** of NEMA procedures for PET acceptance testing and **interpretation of the results.**	Demonstrates a goo**d understanding** of NEMA procedures for PET acceptance testing and **interpretation of the results.**
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to perform PET acceptance testing and commissioning	Is **capable of contributing to acceptance testing** of PET systems. **Requires assistance** to ensure that there are no errors in the process.	Is **capable of performing acceptance testing** of PET systems. Requires only **minimal assistance** Makes **occasional minor errors**.	Is capable of **independently performing acceptance testing** of PET systems to **an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			
Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to perform SUV calibration and check SUV calibration accuracy.	Is **capable of contributing to** SUV calibration and accuracy checks. **Requires assistance** to ensure that there are no errors in the process.	Is **capable of performing** SUV calibration and accuracy checks. Requires only **minimal assistance** Makes **occasional minor errors**.	Is capable of **independently performing S**UV calibration and accuracy checks to **an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

MODULE 6: RADIOACTIVITY MEASUREMENTS AD INTERNAL DOSIMETRY

6.1 Use of traceable standards for radioactivity measurements
6.2 Formalism and application of internal dosimetry
6.3 Radiation dose from diagnostic nuclear medicine radiopharmaceuticals
6.4 Quantitative nuclear medicine imaging
6.5 Patient-specific dosimetry

Sub-module 6.1: Use of Traceable Standards for Radioactivity Measurements

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the traceability chain for radionuclide activity measurements in the nuclear medicine setting.	Demonstrates a **limited understanding** of the traceability chain for radionuclide activity measurements.	Demonstrates a goo**d understanding** of the traceability chain for radionuclide activity measurements.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to apply quality assurance principles and estimate the uncertainties involved in radioactivity measurements in the clinical setting.	Is **capable of applying** quality assurance principles and estimating the uncertainties involved in radioactivity measurements. **Work requires close scrutiny** to ensure that there are no errors in the process.	Is **capable of applying** quality assurance principles and estimating the uncertainties involved in radioactivity measurements. Requires only **minimal assistance** Makes **occasional minor errors**.	Is capable of **independently applying** quality assurance principles and estimating the uncertainties involved in radioactivity measurements **without errors.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 6.2: Formalism and Application of Internal Dosimetry

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the formalism established for internal dose calculations, including its limitations.	Demonstrates a **limited understanding** of the formalism established for internal dose calculations, including its limitations.	Demonstrates a goo**d understanding** of the formalism established for internal dose calculations, including its limitations.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to calculate absorbed dose to organs according to the MIRD formalism as well as to derive the effective dose.	Is capable of calculating absorbed dose to organs according to the MIRD formalism as well as deriving the effective dose**. Results require careful checking.**	Is capable of calculating absorbed dose to organs according to the MIRD formalism as well as deriving the effective dose. R**equires only minor assistance.**	Is capable of **independently** calculating the absorbed dose to organs according to the MIRD formalism as well as deriving the effective dose. **Results are error free.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 6.3: Radiation Dose from Diagnostic Nuclear Medicine Radiopharmaceuticals.

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the underlying methods for the derived tables available for internal dose estimations, including the uncertainties expected for different patients.	Demonstrates a **limited understanding** of the underlying methods for the derived tables available for internal dose estimations, including the uncertainties expected for different patients.	Demonstrates a goo**d understanding** of the underlying methods for the derived tables available for internal dose estimations, including the uncertainties expected for different patients.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to use established tables for estimating absorbed dose and effective dose to the patient.	Is capable of using established tables to estimate absorbed dose and effective dose to the patient. **Calculations require careful checking.**	Is capable of using established tables to estimate absorbed dose and effective dose to the patient. **Requires only minor assistance.**	Is capable of using established tables to estimate absorbed dose and effective dose to the patient **without assistance. Results are error free.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 6.4: Quantitative Nuclear Medicine Imaging.

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the main factors affecting quantitative measurements in nuclear medicine.	Possesses a **basic** understanding of the main factors affecting quantitative measurements in nuclear medicine.	Possesses a **good** understanding of the main factors affecting quantitative measurements from **planar, SPECT and PET images**.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to acquire quantitative measures from planar, SPECT and PET studies.	Is capable of acquiring quantitative measures from planar, SPECT and PET studies. **Requires close supervision.**	Is capable of acquiring quantitative measures from planar, SPECT and PET studies. R**equires only limited assistance.**	Is capable of **independently** acquiring quantitative measures from planar, SPECT and PET studies **to an acceptable clinical standard**.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 6.5: Patient-specific Dosimetry

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the tools and requirements needed for performing patient-specific internal dosimetry.	Possesses a **basic** understanding of the need, tools and requirements for performing patient specific dosimetry.	Possesses a **good** understanding of the need, tools and requirements for performing patient specific dosimetry.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to calculate patient-specific dosimetry from repeat images and uptake measurements.	Is capable of calculating patient-specific dosimetry from repeat images and uptake measurements**. Results require careful checking.**	Is capable of calculating patient-specific dosimetry from repeat images and uptake measurements. R**equires only minor assistance.**	Is capable of **independently** calculating, **without error,** patient-specific dosimetry from repeat images and uptake measurements.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

MODULE 7: QUALITY CONTROL OF NUCLEAR MEDICINE EQUIPMENT

7.1 Design and supervision of a routine QC program
7.2 QC of a dose calibrator
7.3 QC of a scintillation probe and well counter
7.4 QC of a gamma camera and SPECT
7.5 QC of PET/Ct systems
7.6 QC of display and hardcopy devices
7.7 QC of DXA systems

Sub-module 7.1: Design and Supervision of a Routine QC Program

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the methods for the clinical implementation and supervision of a quality control programme.	Demonstrates a **basic understanding** of the generic aspects of a clinical QC programme.	Demonstrates a **good understanding** of the methods of a clinical QC programme.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to manage a QC programme including the appropriate use of instrumentation, test selection and test frequency.	Is **capable of managing a QC programme** including **selection and use of appropriate equipment, test selection and test frequency. Requires assistance** to ensure that there are no errors in the process.	Is capable of managing a QC programme. **Requires only minimal supervision.** Makes **occasional minor errors**.	Is capable of **independently managing a QC programme** to an acceptable clinical standard.
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 7.2: QC of a Dose Calibrator

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the effect of geometry, energy and type of emissions on radioactivity measurements.	Possesses a **basic** understanding of the **QC requirements of a dose calibrator** including the effects of geometry, energy and type of emissions on radioactivity measurements	Possesses a **good** understanding of the **QC requirements of a dose calibrator** including the effects of geometry, energy and type of emissions on radioactivity measurements
Date Achieved		
Supervisor's Initials		

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
The ability to perform basic dose calibrator QC including constancy, background, linearity and accuracy checks and set appropriate action levels.	Is capable of **assisting** with the QC program for a dose calibrator.	Is capable of **performing** most of the QC program for a dose calibrator. **Requires limited supervision.**	Is capable of **independently performing** the QC program for a dose calibrator **to an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 7.3: QC of a Scintillation Probe and Well Counter

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the principles of operation of a scintillation probe and well counter and relevant QC procedures.	Possesses a **basic** understanding of the principles of operation of a scintillation probe and well counter and relevant QC procedures.	Possesses a **good** understanding of the principles of operation of a scintillation probe and well counter and relevant QC procedures.
Date Achieved		
Supervisor's Initials		

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
The ability to perform basic QC procedures for non-imaging scintillation systems	Is capable of **assisting** with the QC program for non-imaging scintillation systems.	Is capable of **performing** most of the QC program for non-imaging scintillation systems. **Requires limited supervision.**	Is capable of **independently performing** the QC program for non-imaging scintillation systems **to an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 7.4: QC of a Gamma Camera and SPECT

Knowledge Base	Level of Competency Achieved	
	2	1
An understanding of QC procedures for planar and SPECT devices.	Possesses a **basic** understanding of relevant QC procedures for planar and SPECT devices.	Possesses a **good** understanding of relevant QC procedures for planar and SPECT devices.
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to perform and evaluate typical planar QC procedures including: spatial resolution and uniformity (integral and differential),	Is capable of **assisting** with the QC program for a planar imaging camera.	Is capable of **performing** most of the QC program for a planar imaging camera. **Requires limited supervision.**	Is capable of **independently performing** the QC program for a planar imaging camera **to an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			
Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to perform and evaluate typical SPECT QC procedures including: spatial resolution, uniformity (integral and differential), COR, spatial resolution SPECT uniformity and tomographic image quality.	Is capable of **assisting** with the QC program for a SPECT camera.	Is capable of **performing** most of the QC program for a SPECT camera. **Requires limited supervision.**	Is capable of **independently performing** the QC program for a SPECT camera **to an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 7.5: QC of PET/CT systems

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Familiarity with routine PET/CT QC procedures.	Possesses a **basic** understanding of relevant QC procedures for PET/CT systems.	Possesses a **good** understanding of relevant QC procedures for PET/CT systems.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to perform routine QC procedures on a PET/CT system and to initiate appropriate corrective action when QC results reveal problems with the PET/CT system performance.	Is capable of **assisting** with the QC program for PET/CT systems.	Is capable of **performing** most of the QC program for PET/CT systems. **Requires limited supervision.**	Is capable of **independently performing** the QC program for PET/CT systems **to an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 7.6: QC of Display and Hardcopy Devices

Knowledge Base (a)	**Level of Competency Achieved**	
	2	**1**
An understanding of quality control procedures for display and hard copy devices.	Possesses a **basic** understanding of relevant QC procedures for display and hard copy devices.	Possesses a **good** understanding of relevant QC procedures for display and hard copy devices.
Date Achieved		
Supervisor's Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
Knowledge of film and other hard copy properties and calibration.	Possesses a **basic** understanding of the properties and calibration of film and other hard copy records.	Possesses a **good** understanding of the properties and calibration of film and other hard copy records.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to perform QC for display and hard copy devices.	Is capable of **assisting** with the QC program for display and hard copy devices.	Is capable of **performing** most of the QC program for display and hard copy devices. **Requires limited supervision.**	Is capable of **independently performing** the QC program for display and hard copy devices **to an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 7.7: QC of DXA Systems

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the theory and operation of DXA equipment and the importance of QC and calibration in the accurate use of normal ranges.	Possesses a **basic understanding** of the theory and operation of DXA equipment and the importance of QC and calibration in the accurate use of normal ranges.	Possesses a **good understanding** of the theory and operation of DXA equipment and the importance of QC and calibration in the accurate use of normal ranges.
Date Achieved		
Supervisor's Initials		

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
The ability to perform QC of DXA equipment.	Is capable of **assisting** with the QC program of DXA equipment.	Is capable of **performing** most of the QC program of DXA equipment. **Requires limited supervision.**	Is capable of **independently performing** the QC program of DXA equipment **to an acceptable clinical standard.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

MODULE 8: RADIONUCLIDE THERAPY USING UNSEALED SOURCES

8.1 Principles of radionuclide therapy
8.2 Facility design for radionuclide therapy
8.3 Treatment procedures
8.4 Selection of radiopharmaceuticals for nuclear medicine therapy
8.5 Dosimetry for radionuclide therapeutic procedures
8.6 Radiation safety precautions for therapy using unsealed radionuclide sources
8.7 Advice to staff, patients and others regarding radiation risk

Sub-module 8.1: Principles of Radionuclide Therapy

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the principles of radionuclide therapy	Possesses a **basic** understanding of the principles of radionuclide therapy.	Possesses a **good** understanding of the principles of radionuclide therapy.
Date Achieved		
Supervisor's Initials		

Date	Supervisor's comments

Sub-module 8.2: Facility Design for Radionuclide Therapy

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the principles of shielding design for the different radionuclide energies used for therapeutic purposes	Demonstrates a **basic understanding** of shielding design for radionuclide energies used in therapeutic Nuclear Medicine.	Demonstrates a **good understanding** of shielding design for radionuclide energies used in therapeutic Nuclear Medicine.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to design satisfactory radiation shielding for the different radionuclide energies used for therapeutic purposes	Is capable of **contributing** to the design of radiation shielding for the different radionuclide energies used for therapeutic purposes. **Requires significant assistance** to ensure the accuracy of the design.	Is capable of designing radiation shielding for the different radionuclide energies used for therapeutic purposes. **Requires only limited assistance** to ensure the accuracy of the design.	Is capable of **independently designing radiation** shielding for the different radionuclide energies used for therapeutic purposes **to an acceptable level.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 8.3: Treatment Procedures

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the purpose, principles and operational procedures of radionuclide therapy	Possesses a **basic** understanding of the purpose, principles and operational procedures of radionuclide therapy	Possesses a **good** understanding of the purpose, principles and operational procedures of radionuclide therapy
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to manage patients appropriately from a radiation safety perspective both pre and post administration of the radionuclide.	Is capable of **assisting** in the appropriate management of patients from a radiation safety perspective both pre and post administration of the radionuclide.	Requires **only limited supervision** in providing appropriate **safe** management of patients from a radiation perspective both pre and post administration of the radionuclide.	Is capable of **independently** providing appropriate **safe** management of patients from a radiation perspective both pre and post administration of the radionuclide.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 8.4: Selection of Radiopharmaceuticals for Nuclear Medicine Therapy.

Knowledge Base (a)	**Level of Competency Achieved**	
	2	**1**
An understanding of the common indications and radiopharmaceuticals used for therapy in nuclear medicine	Possesses a **basic** understanding of the common indications and radiopharmaceuticals used for therapy in nuclear medicine	Possesses a **good** understanding of the common indications and radiopharmaceuticals used for therapy in nuclear medicine
Date Achieved		
Supervisor's Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
Familiarity with the wide range of diseases in which radionuclide therapy is being used and the selection of the appropriate radiopharmaceutical for the specific patient	Possesses a **basic** understanding of the range of diseases for which radionuclide therapy is used and the selection of the appropriate radiopharmaceutical for the specific patient.	Possesses a **good** understanding of the range of diseases for which radionuclide therapy is used and the selection of the appropriate radiopharmaceutical for the specific patient.
Date Achieved		
Supervisor's Initials		

Date	**Supervisor's comments**

Sub-module 8.5: Dosimetry for Radionuclide Therapeutic Procedures

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the principles of internal dosimetry.	Possesses a **basic** understanding of the principles of internal dosimetry	Possesses a **good** understanding of the principles of internal dosimetry
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
An ability to calculate the activity of the administered dose for therapy in nuclear medicine	Is capable of calculating the activity of the administered dose for therapy in nuclear medicine. Results need careful checking.	Requires **only limited assistance** in calculating the activity of the administered dose for therapy in nuclear medicine.	Is capable of **independently** calculating the activity of the administered dose for therapy in nuclear medicine.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 8.6: Radiation Safety Precautions for Therapy using Unsealed Radionuclide Sources

Knowledge Base (a)	**Level of Competency Achieved**	
	2	**1**
Familiarity with all legislations, guidelines and international best practices to ensure radiation safety, before, during and after administration of radionuclide therapy	Demonstrates a **basic understanding** of legislations, guidelines and international best practices and the **principles of hazard assessment and control mechanisms** to ensure radiation safety, before, during and after administration of radionuclide therapy**. Requires assistance** with understanding of the **more difficult aspects.**	Demonstrates a **good understanding** of all legislations, guidelines and international best practices and the **principles of** hazard assessment and control mechanisms to ensure radiation safety, before, during and after administration of radionuclide therapy.
Date Achieved		
Supervisor's Initials		
Knowledge Base (b)	**Level of Competency Achieved**	
	2	**1**
Familiarity with the chemical forms of therapy radiopharmaceuticals and how this would affect their distribution in the environment when excreted by the patient or if spilt from a container	Demonstrates a **basic understanding** of the chemical forms of therapy radiopharmaceuticals and how this would affect their distribution in the environment when excreted by the patient or if spilt from a container**. Requires assistance** with understanding of the **more difficult aspects.**	Demonstrates a **good understanding** of the chemical forms of therapy radiopharmaceuticals and how this would affect their distribution in the environment when excreted by the patient or if spilt from a container**.**
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to apply radiation protection regulations to personnel, patients and members of the public associated with radionuclide therapy	Possesses only a **limited ability** to apply radiation protection regulations to personnel, patients and members of the public associated with radionuclide therapy. **Requires close supervision.**	Requires **only limited assistance** in applying radiation protection regulations to personnel, patients and members of the public associated with radionuclide therapy	Is capable of **independently** applying radiation protection regulations to personnel, patients and members of the public associated with radionuclide therapy
Date Achieved			
Supervisor's Initials			
Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to communicate with the patient, staff and public about the risks associated with handling of high activity unsealed sources	Possesses only a **limited ability** to advise others on the risks associated with handling of high activity unsealed sources and **correct practical aspects to reduce dose.**	Is capable of advising others on the risks associated with handling of high activity unsealed sources and correct practical aspects to reduce dose. Requires **supervision** to ensure that **no incorrect advice** is provided.	Is capable of **independently advising** others on the risks associated with handling of high activity unsealed sources and practical aspects to reduce dose. **The advice provided is at all times correct and appropriate.**
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

MODULE 9: CLINICAL COMPUTING AND NETWORKING

9.1 Operation of a clinical acquisition and processing/reviewing workstation
9.2 Computer system administration management
9.3 First line computer system troubleshooting
9.4 Computer image processing techniques
9.5 Image analysis in a high level programming language (optional)
9.6 Image reconstruction, registration and fusion, and tracer kinetic modelling
9.7 Standard image file formats used in nuclear medicine
9.8 PACS, RIS and HIS
9.9 Software validation: computer simulations, phantoms and clinical data
9.10 Computer networking

Sub-module 9.1: Operation of a Clinical Acquisition and Processing/Reviewing Workstation

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the basic characteristics of workstation operating systems and clinical software for image acquisition and processing.	Demonstrates a **limited understanding** of the basic characteristics of workstation operating systems and clinical software for image acquisition and processing.	Demonstrates a **good understanding** of the basic characteristics of workstation operating systems and clinical software for image acquisition and processing.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to effectively use a workstation operating system and nuclear medicine clinical software	Is **capable** of using a workstation operating system and clinical software for **most simple tasks** associated with image acquisition, display, manipulation and analysis as well as transfer and archiving of data. **Requires assistance** with more complex tasks.	Is **capable of** using a workstation operating system and clinical software for more **complex tasks** associated with image acquisition, display, manipulation and analysis as well as transfer and archiving of data. Requires only **minimal assistance**.	Is capable of **independently** using a workstation operating system and clinical software for **all tasks** associated with image acquisition, display, manipulation and analysis as well as transfer and archiving of data.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 9.2: Computer System Administration Management

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of computer system administration responsibilities and the essential commands, tools and utilities important for ensuring a consistent operation of clinical computer systems.	Demonstrates a **limited understanding** of computer system administration responsibilities and the essential commands, tools and utilities important for ensuring a consistent operation of clinical computer systems.	Demonstrates a **good understanding** of computer system administration responsibilities and the essential commands, tools and utilities important for ensuring a consistent operation of clinical computer systems.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to perform necessary system administration tasks.	Is **capable** of performing **many basic** system administration tasks including planning, installing, supporting and maintaining computer hardware, operating systems, clinical software and networking. **Requires assistance** with more complex tasks.	Is **capable** of performing **all basic** system administration tasks including planning, installing, supporting and maintaining computer hardware, operating systems, clinical software and networking. Requires only **minimal assistance** with more complex tasks.	Is capable of **independently** performing **all** system administration tasks including planning, installing, supporting and maintaining computer hardware, operating systems, clinical software and networking.
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 9.3: First Line Computer System Troubleshooting

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the possible causes of a computer system malfunction.	Demonstrates a **limited understanding** of the possible causes of a computer system malfunction.	Demonstrates a **good understanding** of the possible causes of a computer system malfunction.
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to rapidly recognize and troubleshoot common computer hardware, software and network related problems.	Is **capable** of recognizing and troubleshooting **many** common computer hardware, software and network related problems. **Requires assistance** with **more complex problems.**	Is **capable** of recognizing and troubleshooting **most** common computer hardware, software and network related problems. Requires only **minimal assistance** with more complex problems.	Is capable of **independently** recognizing and troubleshooting **all** common computer hardware, software and network related problems.
Date Achieved			
Supervisor's Initials			
Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to design, schedule and implement computer system preventive maintenance.	Is **capable** of performing **basic** aspects of the design, schedule and implementation of preventive maintenance of a computer system. **Requires assistance** with **more complex aspects.**	Is **capable** of performing **all** aspects of the design, schedule and implementation of preventive maintenance of a computer system. Requires only **minimal assistance** with more complex aspects.	Is capable of **independently** performing **all** aspects of the design, schedule and implementation of preventive maintenance of a computer system.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 9.4: Computer Image Processing Techniques

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the underlying algorithms and programming language mandatory for developing simple image analysis/processing programs in an interactive programming environment.	Demonstrates a **limited understanding** of the algorithms and programming language mandatory for developing simple image analysis/processing programs in an interactive programming environment.	Demonstrates a **good understanding** of the algorithms and programming language mandatory for developing simple image analysis/processing programs in an interactive programming environment.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to develop, test and document efficient image processing routines/applications in a high level programming environment and to utilize macro routines in the vendor's macro utility, for selected clinical tasks.	**Requires considerable assistance** to develop, test and document efficient image processing routines/applications in a high level programming environment and to utilize macro routines in the vendor's macro utility, for selected clinical tasks.	Requires only **minimal assistance** to develop, test and document efficient image processing routines/applications in a high level programming environment and to utilize macro routines in the vendor's macro utility, for selected clinical tasks.	Is capable of **independently** developing, testing and documenting efficient image processing routines/applications in a high level programming environment and utilizing macro routines in the vendor's macro utility, for selected clinical tasks.
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 9.5: Image Analysis in a High Level Programming Language (optional)

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the programming flowcharts and pseudo code, and the transition from this conceptual approach to development of actual programs in a high level language.	Possesses a **good understanding** of programming flowcharts and pseudo code, and a **basic understanding** of the transition from this conceptual approach to development of actual programs in a high level language.	Possesses a **good understanding** of programming flowcharts and pseudo code, **and** of the transition from this conceptual approach to development of actual programs in a high level language.
Date Achieved		
Supervisor's Initials		

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
The ability to write simple, readable and efficient programs in a high level (procedural) language, to test new software and properly document the code.	Is capable of writing **basic** efficient programs in a high level (procedural) language including testing and documentation of new software. **Requires assistance** with **more complex programs.**	Is capable of writing **complex** efficient programs in a high level (procedural) language including testing and documentation of new software. Requires only **minimal assistance**.	Is capable of **independently** writing **complex** efficient programs in a high level (procedural) language including testing and documentation of new software.
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 9.6: Image Reconstruction, Registration and Fusion, and Tracer Kinetic Modelling

Knowledge Base	Level of Competency Achieved	
	2	**1**
An understanding of the algorithms implemented in the software routinely used in the resident's department to perform image reconstruction, registration, fusion and various compensation schemes for physical factors affecting the quality of SPECT and PET images.	Possesses a **basic** understanding of the algorithms implemented in the software routinely used in the resident's department to perform image reconstruction, registration, fusion and various compensation schemes for physical factors affecting the quality of SPECT and PET images.	Possesses a **good** understanding of the algorithms implemented in the software routinely used in the resident's department to perform image reconstruction, registration, fusion and various compensation schemes for physical factors affecting the quality of SPECT and PET images.
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to perform image reconstruction and registration in clinical studies, and to propose, design and optimise/evaluate new reconstruction approaches and compensation schemes for different image degrading factors.	Is **capable** of performing **basic** image reconstruction and registration in clinical studies, and of proposing, designing and optimising/evaluating new reconstruction approaches and compensation schemes for different image degrading factors. **Requires assistance** with **more complex aspects.**	Is **capable** of performing **all** image reconstruction and registration in clinical studies, and of proposing, designing and optimising/evaluating new reconstruction approaches and compensation schemes for different image degrading factors. Requires only **minimal assistance** with more complex aspects.	Is capable of **independently** performing **all** aspects of image reconstruction and registration in clinical studies, and of proposing, designing and optimising/evaluating new reconstruction approaches and compensation schemes for different image degrading factors.
Date Achieved			
Supervisor's Initials			
Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to apply models for the analysis of tracer kinetics	Is capable of applying **simple** models for analysis of tracer kinetics. R**equires significant assistance** with **more complex models.**	Is capable of applying **simple and complex** models for analysis of tracer kinetics. R**equires only limited assistance**.	Is capable of **independently** applying **simple and complex** models for analysis of tracer kinetics.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 9.7: Standard Image File Formats used in Nuclear Medicine

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the structure and properties of image file formats commonly utilised in nuclear medicine.	Demonstrates a **limited understanding** of the structure and properties of image file formats commonly utilised in nuclear medicine.	Demonstrates a **good understanding** of the structure and properties of image file formats commonly utilised in nuclear medicine.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to read, display and manipulate medical image data provided in commonly used formats (Interfile 3.3, DICOM 3.0).	Is capable of reading, displaying and manipulating medical image data provided in commonly used formats. **Requires considerable assistance with more complex aspects.**	Is capable of reading, displaying and manipulating medical image data provided in commonly used formats. **Requires only limited assistance with more complex aspects**.	Is capable of **independently** reading, displaying and manipulating medical image data provided in commonly used formats **including the more complex aspects**.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 9.8: Computer networking, PACS, RIS and HIS

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of PACS technology and acceptance testing procedures as well as the essentials of RIS and HIS.	Demonstrates a **basic understanding** of PACS technology and acceptance testing procedures as well as the essentials of RIS and HIS.	Demonstrates a **good understanding** of PACS technology and acceptance testing procedures as well as the essentials of RIS and HIS. **Also** possesses a **good** understanding of the requirements to ensure that the system will meet the user's technical, functional and safety requirements.
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
The **ability** to participate in the maintenance of computer hardware and software that comprise a computer network, including the use, configuration and monitoring of active network equipment.	Possesses a **limited ability** to participate in the maintenance of computer hardware and software that comprise a computer network, including the use, configuration and monitoring of active network equipment. Requires **significant assistance**.	Possesses a **good ability** to participate in the maintenance of computer hardware and software that comprise a computer network, including the use, configuration and monitoring of active network equipment. Requires **only limited assistance**.	Is capable of **independent input** to the maintenance of computer hardware and software that comprise a computer network, including the use, configuration and monitoring of active network equipment.
Date Achieved			
Supervisor's Initials			
Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to contribute to competent decisions related to selection of PACS that best meets the NM department needs based on its key characteristics and features.	Is capable of **contributing** to decisions related to selection of a PACS system based on its key characteristics and features **Requires significant assistance** with **some** of the concepts involved.	Is capable of **contributing** to decisions related to selection of a PACS system based on its key characteristics and features **Requires only limited assistance** with **some** of the concepts involved.	Is capable of **independently providing** the **"physics" input** to decisions related to selection of a PACS system based on its key characteristics and features.
Date Achieved			
Supervisor's Initials			

Practical Skills (c)	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to effectively use NM workstations, servers and PACS linked to the local RIS or HIS and those linked to an external PACS system.	Is capable of performing **most simple tasks associated with** data retrieval and storage using a workstation, server and PACS linked to the local RIS or HIS and those linked to an external PACS system. **Requires assistance** with more complex tasks.	Is capable of performing **all necessary tasks associated with** data retrieval and storage using a workstation, server and PACS linked to the local RIS or HIS and those linked to an external PACS system. Requires only **minimal assistance**.	Is capable of **independently** performing **all necessary tasks associated with** data retrieval and storage using a workstation, server and PACS linked to the local RIS or HIS and those linked to an external PACS system.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 9.9: Software Validation: Computer Simulations, Phantoms and Clinical Data

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An **understanding** of the components of a Monte Carlo simulation method: computer generated phantoms, models of the imaging process, fast computational methods, and the use of physical phantoms and methods of clinical validation.	Possesses a **basic** understanding of Monte Carlo simulation methods computer generated phantoms, models of the imaging process, fast computational methods, and the use of physical phantoms and methods of clinical validation**.**	Possesses a **good** understanding of Monte Carlo simulation methods computer generated phantoms, models of the imaging process, fast computational methods, and the use of physical phantoms and methods of clinical validation**.**
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
The **ability** to perform MC simulations with one of the NM related simulation programs and properly interpret results.	Possesses a **limited ability** to perform MC simulations with one of the NM related simulation programs. Requires **significant assistance** to ensure the efficacy of the results.	Possesses a **good ability** to perform MC simulations with one of the NM related simulation programs **and properly interpret results**. Requires **only limited assistance** to ensure the efficacy of the results.	Is capable of **independently** performing MC simulations with one of the NM related simulation programs and properly interpreting the results.
Date Achieved			
Supervisor's Initials			

Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
The **ability** to assist in designing a clinical validation study with a goal to bring an appreciable improvement in image quality, quantitative accuracy and image reader's confidence.	Possesses a **limited ability** to assist in the design of a clinical validation study. Requires **significant assistance**.	Possesses a **good ability** to assist in the design of a clinical validation study. Requires **only limited assistance**.	Is capable of **independently** assisting in the design of a clinical validation study.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

MODULE 10: CLINICAL APPLICATIONS

10.1 Protocols for routine clinical procedures
10.2 Common artefacts in clinical images
10.3 Analysis of common clinical studies and sources of error
10.4 Principles and physiological basis for common clinical studies
10.5 Developing clinical protocols for the estimation of patient dosimetry
10.6 Optimization
10.7 The physiological basis of PET imaging

Sub-module 10.1: Protocols for Routine Clinical Procedures

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Familiarity with the effect of technical factors and acquisition protocol on the final result of a clinical procedure.	Possesses a **basic** understanding of the effect of technical factors and acquisition protocol on the final result of a clinical procedure.	Possesses a **good** understanding of the effect of technical factors and acquisition protocol on the final result of a clinical procedure.
Date Achieved		
Supervisor's Initials		

Date	**Supervisor's comments**

Sub-module 10.2: Common Artefacts in Clinical Images

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Familiarity with common image artefacts, their causes, and how to deal with them.	Possesses a **basic** understanding of common image artefacts and their causes. **Yet to understand how to deal with them.**	Possesses a **good** understanding of common image artefacts, their causes **and** how to deal with them**.**
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to identify artefacts in nuclear medicine images, identify their probable causes and undertake remedial action.	Is capable of identifying **many of the artefacts** in nuclear medicine images and their probable causes. **Requires assistance** with proposing remedial action to be taken.	Is capable of identifying **most** of the artefacts in nuclear medicine images, their probable causes and applying remedial action with **only limited assistance**.	Is capable of **independently** identifying artefacts in nuclear medicine images, their probable causes and applying remedial action.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 10.3: Analysis of Common Clinical Studies and Sources of Error

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Familiarity with sources of error in clinical procedures, their impact on the patient and how to validate clinical procedures.	Possesses a **basic** understanding of sources of error in clinical procedures, their impact on the patient and how to validate clinical procedures.	Possesses a **good** understanding of sources of error in clinical procedures, their impact on the patient and how to validate clinical procedures.
Date Achieved		
Supervisor's Initials		

Date	**Supervisor's comments**

Sub-module 10.4: Principles and Physiological Basis for Common Clinical Studies

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
To understand the physiology of the principal organ systems of the body, and how nuclear medicine can be used to elucidate information about the function of these organ systems.	Possesses a **basic** understanding of the **normal and abnormal** physiology of the principal organ systems of the body, and how nuclear medicine can be used to elucidate information about the function of these organ systems.	Possesses a **good** understanding of the **normal and abnormal** physiology of the principal organ systems of the body, and how nuclear medicine can be used to elucidate information about the function of these organ systems.
Date Achieved		
Supervisor's Initials		

Date	Supervisor's comments

Sub-module 10.5: Developing Clinical Protocols for the Estimation of Patient Dosimetry

Practical Skills	Level of Competency Achieved		
	3	**2**	**1**
The ability to estimate the patient dose associated with a new nuclear medicine investigation.	Is capable of calculating patient dose associated with a new nuclear medicine investigation**. Results require careful checking.**	Is capable of calculating patient dose associated with a new nuclear medicine investigation**. Requires only minor assistance to ensure error free results.**	Is capable of **independently** calculating, **without error,** patient dose associated with a new nuclear medicine investigation**.**
Date Achieved			
Supervisor's Initials			

Date	Supervisor's comments

Sub-module 10.6: Optimization

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of the procedures used for risk/benefit evaluation of diagnostic and therapeutic nuclear medicine procedures.	Possesses a **basic** understanding of the procedures used for risk/benefit evaluation of diagnostic and therapeutic nuclear medicine procedures.	Possesses a **good** understanding of the procedures used for risk/benefit evaluation of diagnostic and therapeutic nuclear medicine procedures.
Date Achieved		
Supervisor's Initials		

Practical Skills (a)	**Level of Competency Achieved**		
	3	**2**	**1**
To be able to evaluate diagnostic nuclear medicine procedures and diagnostic information with respect to absorbed dose to the patient.	Requires **significant assistance** with the evaluation of diagnostic nuclear medicine procedures and diagnostic information with respect to absorbed dose to the patient.	Requires **only limited assistance** with the evaluation of diagnostic nuclear medicine procedures and diagnostic information with respect to absorbed dose to the patient.	Is capable of **independently evaluating** diagnostic nuclear medicine procedures and diagnostic information with respect to absorbed dose to the patient.
Date Achieved			
Supervisor's Initials			

Practical Skills (b)	**Level of Competency Achieved**		
	3	**2**	**1**
To be able to evaluate radionuclide therapy procedures with respect to possibility of cure and risk for complications.	Requires **significant assistance** with the evaluation of radionuclide therapy procedures with respect to possibility of cure and risk for complications.	Requires **only limited assistance** with the evaluation radionuclide therapy procedures with respect to possibility of cure and risk for complications.	Is capable of **independently evaluating** radionuclide therapy procedures with respect to possibility of cure and risk for complications.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 10.7: The Physiological Basis of PET Imaging

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
To understand the principles and physiological basis for common clinical PET and PET/CT studies.	Demonstrates a **basic** understanding of the principles and physiological basis for common clinical PET and PET/CT.	Demonstrates a **good** understanding of the principles and physiological basis for common clinical PET and PET/CT.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
The ability to recognise the normal appearances for brain, heart and whole body studies as well as common abnormal appearances and artefacts.	**Requires assistance** to recognise normal appearances for brain, heart and whole body studies. Has **difficulty in differentiating** normal appearances from abnormal appearances and artefacts.	Is capable of recognising normal appearances for brain, heart and whole body studies and in **differentiating most** abnormal appearances and artefacts from normal appearances.	Is capable of recognising normal appearances for brain, heart and whole body studies and **differentiating** abnormal appearances and artefacts from normal appearances.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

MODULE 11: PREPARATION AND QUALITY CONTROL OF RADIOPHARMACEUTICALS

11.1: Production and preparation of radiopharmaceuticals
11.2: Quality control of radiopharmaceuticals

Sub-module 11.1: Production and Preparation of Radiopharmaceuticals

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
Familiarity with the facilities necessary for the production of radionuclides and radiopharmaceuticals.	Possesses a **basic** understanding of the facilities necessary for the production of radionuclides and radiopharmaceuticals.	Possesses a **good** understanding of the facilities necessary for the production of radionuclides and radiopharmaceuticals.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Ability to apply appropriate protocols to prepare Tc-99m-labelled radiopharmaceuticals.	Is capable of preparing Tc-99m-labelled radiopharmaceuticals which i**nvolve simple protocols**. Requires **close supervision.**	Is capable of preparing Tc-99m-labelled radiopharmaceuticals which i**nvolve complex protocols**. **Requires supervision.**	Is capable of **independently** preparing Tc-99m-labelled radiopharmaceuticals.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

Sub-module 11.2: Quality Control of Radiopharmaceuticals

Knowledge Base	**Level of Competency Achieved**	
	2	**1**
An understanding of quality control procedures and their importance for radiopharmaceuticals.	Possesses a **basic** understanding of QC procedures for radiopharmaceuticals.	Possesses a **good** understanding of QC procedures for radiopharmaceuticals.
Date Achieved		
Supervisor's Initials		

Practical Skills	**Level of Competency Achieved**		
	3	**2**	**1**
Be able to perform basic QC tests of radiopharmaceuticals.	Is capable of performing basic QC tests of **some** radiopharmaceuticals **under close supervision**.	Is capable of performing basic QC tests of radiopharmaceuticals. Requires only **limited supervision**.	Is capable of **independently** performing basic QC tests of radiopharmaceuticals.
Date Achieved			
Supervisor's Initials			

Date	**Supervisor's comments**

APPENDIX VI

SUPPLEMENTARY FORMS AND DOCUMENTS

APPLICATION FOR ENTRY

AS A RESIDENT TO THE

CLINICAL TRAINING PROGRAMME

IN NUCLEAR MEDICINE PHYSICS

ADMINISTERED BY

_____

Family Name: .....**Given Names**:.....……..
(In BLOCK letters) (In BLOCK letters.)
Please highlight the name you prefer to be called by.

Please tick appropriate box

☐ **Ms** ☐ **Mr**

Personal Details of Applicant

(please complete all details In BLOCK letters)

Address: .....……

.....……

.....…….....

Postcode: .....

Telephone Number: ..... Fax: ……

Email: ……..

Previous Academic Record

A copy of the degree(s) and/or transcript(s) of the academic record in the original language (and English translation if not in English) must be attached to this application and forwarded to the National Programme Coordinator.

Undergraduate Education:

Name of Institution: .....….

Address of Institution: …….....

Year commenced: ……. Year Completed: …….

Name of degree obtained: ……

Majoring in: ….…….

Post Graduate Education in Medical Physics:

Name of Institution: .....….

Address of Institution: …….

Year Commenced: ……. Year Completed: …….

Name of Degree Obtained: ……..……

Majoring in:…….

Other Post Graduate Education:

Name of Institution: .....….

Address of Institution: …….

Year Commenced: ……. Year Completed: …….

Name of Degree Obtained: ……..……

Majoring in:…….

Attach additional pages if required.

To be signed by The National Programme Coordinator:

I have sighted the applicant's degree(s) and/or transcript(s) of their academic record in the original language (and English translation if not in English). These qualifications are appropriate for the applicant to enter the Clinical Training Programme for Nuclear Medical Physicists in (insert name of member state).

Signed :…….……. Date: ……/……/……..

National Programme Coordinator for (insert name of member state).

Training Program Details

In-Service Clinical Training Position:

Name of Clinical Department: ……....

Address of Clinical Department: …….

…….

…… Postcode: .....

Chief Physicist[12]: ……

Telephone Number: ..... Fax Number: .....

Email: ……..

Clinical Supervisor (if known): ……

Telephone Number: ..... Fax Number: .....

Email: ……..

Employment details of Resident

Date Commenced/Commencing: ……..

Full or Part Time: ……

☐ Permanent ☐ Temporary

if temporary please state duration: ……

To be signed on behalf of the employer[1]:

I certify that the applicant has been accepted for an In-Service Clinical Training Position in this department and that the details of the In-Service Clinical Training Position provided above are correct.

Endorsed by:…. Date: ……/……/……..
(signed on behalf of the employer)

Name in BLOCK letters ……..

Position (example Head of Department)……..

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[12] This refers to the person who is overall responsible for the medical physics service in which the resident is being trained.

Statement by the Applicant

I hereby apply to undertake the Clinical Training Programme in Nuclear Medicine Physics.

I agree that the statements made by me in this application are correct to the best of my knowledge.

APPLICANT'S SIGNATURE: …… DATE: …….

Instructions to the Applicant

Please ensure that:

- *a copy of your **degree(s) and/or transcript(s) of your academic record** in the original language (and English translation if not in English) is attached to this application form, and*
- *the Head of Department or other appropriate authority has signed the **"Training Programme Details"** section (confirming that you have been accepted into a clinical training position).*

This application should be sent by either post or email to the National Programme Coordinator. Electronic signatures are acceptable

You will be advised of the outcome of your application.

Contact details for the National Programme Coordinator

Insert contact details for NPC

CHECKLIST FOR NEW RESIDENTS

(0-3 MONTHS OF TRAINING PROGRAMME)

RESIDENT: _____

DATE OF COMMENCEMENT OF RESIDENCY: _____

	date achieved
ALLOCATION OF A CLINICAL SUPERVISOR	
RESIDENT'S APPLICATION FORM SENT TO NATIONAL PROGRAMME COORDINATOR	
LETTER OF ACCEPTANCE INTO TRAINING PROGRAMME RECEIVED FROM NATIONAL PROGRAMME COORDINATOR	
ORIENTATION BY CLINICAL SUPERVISOR	
RESIDENT STARTS A LOGBOOK (if required)	
CLINICAL TRAINING GUIDE PROVIDED TO RESIDENT	
SCHEDULE FOR REGULAR SUPERVISOR-RESIDENT MEETINGS ESTABLISHED (at least monthly)	
INITIAL 6 MONTH TRAINING PLAN AGREED	
TRAINING PLAN FOR PERIOD OF ENROLLMENT DEVELOPED AND AGREED WITH CLINICAL SUPERVISOR	
RESIDENT BEGINS ATTENDANCE AT CLINICAL MEETINGS AND/OR TUTORIALS	

WORK PLAN AGREEMENT

FOR _____(insert name of Resident)

FOR THE SIX MONTH PERIOD from _____/____/_____ to ____/____/____

Month Specify e.g. Jan	**Sub-modules to be worked on**	**Pre-requisite knowledge to be acquired by (date)**	**Competency assessment schedule (date)**	**Resources/strategies (if necessary use notes section below)**
1.				
2.				
3.				

WORK PLAN AGREEMENT (CONT'D)

Month Specify e.g. Jan	Sub-modules to be worked on	Pre-requisite knowledge to be acquired by (date)	Competency assessment schedule (date)	Resources/strategies (if necessary use notes section below)
4.				
5.				
6.				

WORK PLAN AGREEMENT (CONT'D)

RESOURCES AND STRATEGIES

Notes:_____

_____

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SIGNED:

_____(Resident)

_____(Clinical Supervisor)

SUMMARY OF SCHEDULE FOR COMPLETION OF CLINICAL TRAINING PROGRAMME

Level of competency to be obtained and assessed by end of period specified.

SUB-MODULE/ COMPETENCY	**Year of Training Specify e.g. 2008**						
	1 _____		2 _____		3 _____		4 _____
	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June
1.1							
1.2							
1.3							
1.4							
2.1							
2.2							
2.3							
2.4a							
2.4b							
2.4c							
2.5							
2.6							
2.7							
2.8							
2.9							
3.1							
3.2							
3.3							
3.4							
3.5							
3.6							

SUMMARY OF SCHEDULE FOR COMPLETION OF CLINICAL TRAINING PROGRAMME (cont'd)

Level of competency to be obtained and assessed by end of period specified.

SUB-MODULE/ COMPETENCY	Year of Training Specify e.g. 2008						
	1 _____		2 _____		3 _____		4 _____
	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June
4.1							
4.2							
4.3a							
4.3b							
4,3c							
4.4a							
4.4b							
4,4c							
4.5a							
4.5b							
4,5c							
4.6							
4.7							
4.8a							
4.8b							
5.1							
5.2a							
5.2b							
5.2c							
5.3							
5.4a							
5.4b							
5.5a							

SUMMARY OF SCHEDULE FOR COMPLETION OF CLINICAL TRAINING PROGRAMME (cont'd)

Level of competency to be obtained and assessed by end of period specified.

SUB-MODULE/ COMPETENCY	Year of Training Specify e.g. 2008						
	1 _____		2 _____		3 _____		4 _____
	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June
5.5b							
5.5c							
5.5d							
6.1							
6.2							
6.3							
6.4							
6.5							
6.6a							
6.6b							
6.7a							
6.7b							
6.8c							
6.8							
7.1							
7.2							
7.3							
7.4							
7.5							
7.6							
8.1							
8.2							

ASSIGNMENT SCHEDULE

	Year of Training Specify e.g. 2008					
	1 _____		2 _____		3 _____	
	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec
ASSIGNMENT 1.						
Topic selected						
Assignment submitted						
Assessed as satisfactory						
ASSIGNMENT 2.						
Topic selected						
Assignment submitted						
Assessed as satisfactory						
ASSIGNMENT 3.						
Topic selected						
Assignment submitted						
Assessed as satisfactory						

PORTFOLIO PREPARATION SCHEDULE

	Year of Training **Specify e.g. 2008**					
	1 _____		2 _____		3 _____	
	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec
Curriculum Vitae prepared and updated (at least annually)						
Progress Reports completed by Resident and Clinical Supervisor						
Samples of Work						
SAMPLE 1						
Area and nature of sample selected						
Sample of work Prepared						
SAMPLE 2						
Area and nature of sample selected						
Sample of work Prepared						
SAMPLE 3						
Area and nature of sample selected						
Sample of work Prepared						
SAMPLE 4						
Area and nature of sample selected						
Sample of work Prepared						
SAMPLE 5						
Area and nature of sample selected						
Sample of work Prepared						

SIX MONTH PROGRESS REPORT FORM

Resident: _____ Clinical Supervisor: _____
(insert names in BLOCK LETTERS)

Date of this Report: ____/____/____
Date of Commencement in the Training Programme: ____/____/____

The Report is an opportunity for you and your Clinical Supervisor to assess how your clinical training has progressed over the past 6 months, to re-formulate your work-plan for the next 6 months and to revise your schedule for completion (if necessary) and to review all aspects of your Residency. It is expected that your Clinical Supervisor will read and discuss this progress report with you.

It is particularly important that you report any obstacles to progress (lack of access to equipment, illness, etc.) and that you're Clinical Supervisor indicates actions taken to address the issues (where appropriate).

SUMMARY OF PROGRESS IN THIS 6 MONTH PERIOD
(to be completed by the Resident)

Sub-modules worked on Competency level achieved (if assessment conducted)													
Sub-modules worked on													
Competency level achieved (if assessment conducted)													
Scheduled assignment submitted (yes/no/not applicable)													
Scheduled sample for portfolio prepared (yes/no/not applicable)													
Other (e.g. seminar presentation, research project)													

DEVELOPMENT OF PROFESSIONAL ATTRIBUTES
(to be completed by the Clinical Supervisor).

Generic Skill	Indicate your assessment of the Resident's capabilities in relation to the following professional attributes. Is there evidence of development or acquisition of this skill in the Resident's Portfolio?
Communication	
Initiative	
Motivation	
Problem Solving	
Safe work practice	
Teamwork	
Technical skills	
Time management	
Up-dates knowledge	

STATEMENT BY CLINICAL SUPERVISOR

I have discussed the attached summary of progress in this reporting period with the Resident and believe that it reflects the progress made in the past six months. The status of this Resident's Clinical Training Programme is considered to be

☐ **Satisfactory** (The Resident is on schedule to complete the training programme by the agreed date)

☐ **Somewhat behind schedule: Progress has been impeded – as a result of**

A ☐ **Issues, beyond the control of the Resident, which have now been resolved,**

or

B ☐ **Issues yet to be resolved**

These issues are described in the comments section of this report which also indicates the remedial actions taken. A revised schedule for completion has been developed and agreed to by the Resident and Clinical Supervisor.

☐ **Unsatisfactory**

Issues, as indicated below, need to be resolved.
A follow-up progress report is required from the Resident in 3 months

Comments by Resident: (Attach additional pages if necessary. Please indicate any concerns/obstacles you may have experienced which have affected progress)

Comments by Clinical Supervisor: (Attach additional pages if necessary. Please comment on remedial actions proposed to address any concerns indicated by the Resident.)

Signatures:
I agree that this report provides an accurate summary of progress in the clinical training programme of the named Resident and that any remedial action necessary to address obstacles to progress have been agreed to by both the Resident and Clinical Supervisor.

Resident _____

Clinical Supervisor: _____

ANNUAL CHECKLIST FOR RESIDENTS (3 months to completion)

RESIDENT: _____

YEAR: 1 2 3 4 5 (please circle)

YEAR: 20____

	✓ when satisfactory	Comment
REGULAR SUPERVISOR-RESIDENT MEETINGS HELD (at least monthly)		
RESIDENT LOGBOOK UP TO DATE		
COMPETENCY ASSESSMENT UP TO DATE		
SIX MONTHLY SUPERVISOR REPORTS COMPLETED (AND FORWARDED TO NATIONAL PROGRAMME COORDINATOR		
ANNUAL REVIEW AND REPORT ON FILE		
ANNUAL TRAINING PLAN UP TO DATE		
TRAINING PLAN FOR PERIOD OF ENROLLMENT UP TO DATE		
RESIDENT REGULARLY ATTENDING CLINICAL MEETINGS AND/OR TUTORIALS		
AT LEAST 5 KEY PORTFOLIO REPORTS TARGETTED FOR ASSESSMENT ARE PLANNED OR UNDER DEVELOPMENT		
ASSIGNMENT FOR THIS YEAR COMPLETED		

COMPLETION CHECKLIST FOR RESIDENTS

RESIDENT: _____

COMPLETION OF REQUIREMENTS CHECKLIST	**Date achieved**
Required level of competency attained in all sub-modules	
Portfolio completed and assessed as satisfactory	
Three assignments completed and graded as 3 or better.	
Oral exam conducted and assessed as satisfactory	
Practical exam conducted and assessed as satisfactory (if required)	

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

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[3] INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS, IOMP Policy Statement No. 2, Basic. Requirements for Education and Training (in press).

[4] NG, K.H., et al., The role, responsibilities and status of the clinical medical physicist in AFOMP, Australas Phys Eng Sci Med **32** 4 (2009) 175-9.

[5] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Alternative Clinical Training Pathways for Medical Physicists, AAPM Rep. 133, New York (2008). http://www.aapm.org/pubs/reports/RPT_133.pdf.

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Clinical training of medical physicists specializing in radiation oncology, Training Course Series, 37, IAEA, Vienna (2009). http://www-pub.iaea.org/MTCD/publications/PDF/TCS-37_web.pdf.

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Clinical Training of Medical Physicists Specializing in Diagnostic Radiology, Training Course Series, No. 47, IAEA, Vienna (2010). http://www-pub.iaea.org/MTCD/publications/PDF/TCS-47_web.pdf.

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Consultants meetings

Vienna, Austria: 25–28 May, 2009; Brisbane, Australia: 27–30 October 2009.

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ISSN 1018–5518