Australasian College of Physical Scientists
and Engineers in Medicine

Accreditation

In

Radiotherapy Equipment Commissioning & Quality Assurance

Candidates Kit

March 2005

Contents

1. Introduction

This document describes the Accreditation in Radiotherapy Equipment Commissioning and Quality Assurance (hereafter called the Accreditation Program) provided by the Australasian College of Physical Sciences and Engineers in Medicine (ACPSEM). It covers all aspects of the Accreditation Program including the scope, competencies, application procedure, assessment, syllabus, reading list, application form, example questions for the written examination, and example assignments for the practical examination.

The ACPSEM currently provides two accreditation programs for medical physicists in radiation oncology:-

- This Accreditation Program;
- Training, Education and Accreditation Program in Radiation Oncology Medical Physics (TEAP).

This Accreditation Program is intended for experienced medical physicists already working in radiation oncology. The TEAP is a broader, more formal training scheme for medical physicists who are appointed to a registrar (training) position. Medical physics registrars must satisfy the ACPSEM training and education requirements to qualify as a medical physics specialist in radiation oncology medical physics. Further information about the TEAP can be obtained from the ACPSEM website (http://www.acpsem.org.au).

It is intended that this Accreditation Program will continue until approximately 2008 when it will be phased out. During that time, an upgrade path will be provided by the ACPSEM to convert Accreditation in Radiotherapy Equipment Commissioning and Quality Assurance to the Accreditation in Radiation Oncology Medical Physics.

An Accreditation Panel of Examiners in Radiation Oncology Medical Physics is responsible for the examining of medical physicists in this specialty. It is responsible to the Council of the ACPSEM through the Professional Standards Board for management of the accreditation programs and examination of candidates. For the remainder of this document, the Accreditation Panel of Examiners in Radiation Oncology Medical Physics will be referred to as the Accreditation Panel. The Accreditation Panel consists of a Chairman and at least four other accredited radiation oncology medical physicists approved by the ACPSEM Council.

2. Scope of the Accreditation Program

Candidates must satisfy the Accreditation Panel that they have the knowledge and skills necessary to successfully plan, implement and carry out acceptance testing, commissioning, calibration and an on-going quality assurance program without supervision for the following categories of radiotherapy equipment:-

(i) Medical electron accelerators (excluding betatrons and including MLC & EPID)
(ii) Orthovoltage X-ray units
(iii) Superficial X-ray units
(iv) Simulators (including CT options)

Accessories such as patient support and immobilisation systems, beam modifiers, tertiary collimation systems and beam direction devices normally used in conjunction with the above items are included. The radiation shielding design and evaluation of the rooms housing this equipment, all radiation beam data associated with treatment planning together with its relevancy to treatment are also included. Absolute dosimetry shall be performed using protocols recommended by the ACPSEM.

The required knowledge and competencies are described in more detail in the next section and in Appendix B.

Please be advised that, from January 2006, the following changes will be made to the scope of the Accreditation Program:-

- all aspects of CT scanners used for virtual simulation will be added
- the x-ray tube, generator & imaging aspects of the simulator will be added

3. Knowledge & Competencies[1]

Radiotherapy Equipment Quality Assurance

- Knowledge of the operation of the equipment listed in Section 2.
- Knowledge of the relevant international and national recommendations, protocols and standards relating to the performance and the quality assurance of the equipment listed in Section 2.
- Knowledge of the correct operating conditions & alignment for the equipment listed in Section 2.
- Knowledge of methods to test the operating conditions and alignment of the equipment listed in Section 2 including performance parameters & tolerances and the appropriate use of these test methods.
- Perform quality assurance procedures on the equipment listed in Section 2 including the tests performed initially after installation and those performed as part of the ongoing monitoring and assessment of equipment performance.
- Diagnose, by physics tests & measurements, the cause of equipment performance being outside acceptable limits.
- Assess the need for quality assurance tests and safety of equipment to be returned to clinical use after maintenance, repair or adjustment.
- Design and implement quality assurance procedures on the equipment listed in Section 2 including the tests performed initially after installation and those performed as part of the ongoing monitoring and assessment of equipment performance.
- Develop a quality assurance test method for a particular performance parameter for the equipment listed in Section 2.

1 The knowledge and competencies specified here are a subset of those in contained in ACPSEM (2003), "Knowledge and Competencies Required For Radiation Oncology Medical Physics".

Radiation Dosimetry

- Knowledge of the characteristics of the therapeutic radiation beams produced by equipment listed in Section 2.
- Knowledge of the principles of operation of dosimeters used in radiotherapy and the appropriate usage for absolute and relative dosimetry in therapeutic radiation beams.
- Knowledge of the relevant international and national recommendations, protocols and standards relating the dosimetry equipment and the measurement of kilovoltage & megavoltage dose.
- Knowledge of methods for the correct testing and use of dosimeters in external beam radiotherapy.
- Perform absolute dose calibration of therapeutic treatment beams using protocol endorsed by the ACPSEM.
- Perform relative dosimetric measurements in phantoms.
- Perform the quality assurance tests which monitor and maintain the accuracy and reliability of both the dosimeters and the dosimetric data measured with those dosimeters.
- Design and implement of a comprehensive quality assurance programme which monitors and maintains accuracy and reliability of both the dosimeters and the dosimetric data measured with those dosimeters for external beam radiotherapy.
- Design and implementation of a dosimetry programme for megavoltage photon and electron beams, and for superficial/orthovoltage beams so that accurate absorbed dose determinations will be obtained
- Design dosimetric phantoms.
- Measure beam data appropriate for use in treatment planning so that individual patient dose calculations are possible by manual and computerised treatment planning methods. Quantify the accuracy of this data and set clear limits on its usage.

RadiotherapyTreatment Planning

- Knowledge of the various algorithms used to calculate dose within the patient in external beam radiotherapy treatment planning.
- Knowledge of the parameters and radiation beam data required by computer systems for megavoltage external beam treatment planning.
- Knowledge of the dose calculation process, parameters used in the calculations and its relationship to absolute calibration.
- Calculate monitor units (and/or time calculations), taking into account field size factors, wedge factors, change in SSD, and any other factors in common use.
- Determine dose at a depth with photon or electron beams.
- Knowledge of the use of localisation, collimation & immobilisation devices.

Radiation Safety and Protection

- Knowledge of the 'System of Radiological Protection' as described by the ICRP and the basic principles of radiation safety.
- Knowledge of international recommendations, national and state legislation.
- Knowledge of the regulatory requirements for radiation safety pertinent to their department.
- Knowledge of safe work practices and emergency procedures for equipment listed in Section 2.

- Knowledge of the selection, calibration and principles of survey meters.
- Knowledge of the calculation of risks associated with radiation exposure.
- Knowledge of the principles and practice of personnel monitoring.
- Knowledge of the local implementation of radiation safety guidelines and requirements.
- Knowledge of the choice of room design, materials used and their thickness.
- Knowledge of the various radiation safety interlocks required on equipment listed in Section 2.
- Knowledge of correct operational procedures in the use of equipment listed in Section 2 such that staff, patients and the general public have minimal dose as per the ALARA principle.
- Analyse procedures and be able to instruct staff on the safe operation of equipment listed in Section 2.
- Knowledge of the response procedures in the event of unnecessary dose to one or more individuals.
- Knowledge of the response procedures in the event of equipment malfunction.
- Knowledge of the precautions to take against and the actions needed for any other credible radiation emergency which could arise in the Radiation Oncology Department.
- Perform an investigation, measurements, dose & risk assessment and prepare a report following a radiation incident.
- Oversee a staff monitoring dosimeter system for assessment of dose to staff and maintaining accurate and reliable records of this system
- Perform radiation survey measurements with an appropriate instrument.
- Advise on new or modified buildings for housing therapy facilities including radiation shielding design and other physical factors
- Perform radiation safety calculations and assessment of buildings and installations both prior to and after construction
- Generate and critically review radiation safety and control administrative procedures which include responsibilities, record keeping, calibration, personnel monitoring, incident and accident management
- Verify safety procedures and features on machines, interlocking and safety barriers
- Coordinate the keeping of radiation safety records
- Implement or complete the requirements for licences/registrations or permits.
- Interpret and implement legislative requirements in relation to radiation apparatus

General

- Knowledge of quality management and quality systems and its application in radiation oncology
- Establish techniques and protocols for radiation dosimetry which conform to national and international standards of practice.
- Maintain a record (for at least the time specified for regulatory or legal requirements) by workbooks for all installations, commissioning, acceptance tests, maintenance and clinical patient measurements obtained for the equipment listed in Section 2.
- Prepare and maintain data manuals used in treatment planning procedures.
- Advise on equipment acquisition.
- Plan and coordinate the commissioning of new installations of equipment listed in Section 2 in association with other professional and technical staff.

- Prepare specifications for new items of equipment listed in Section 2 in association with other professional and technical staff.
- Supervise the maintenance of equipment listed in Section 2 and subsequent verification to ensure accurate delivery of radiation dose to patients.
- Prepare operational procedures for the use of equipment listed in Section 2.
- Plan and coordinate the quality assurance and quality control of equipment listed in Section 2 and associated procedures.

Professional

- Safely work without supervision[2]:-

  (i) Identify & define a problem and formulate strategies for solving it
  (ii) Approach work analytically and thoroughly
  (iii) Critically evaluate processes and outcomes
  (iv) Take due care with the work.
  (v) Apply quality management strategies to the work
  (vi) Interpret novel or non-standard data
  (vii) Make value judgements in unfamiliar situations
  (viii) Be self assured & "think well on their feet"
  (ix) Communicate scientific information clearly and accurately to others
  (x) Recognise fault situations and take suitable corrective action
  (xi) Appreciate the limitations of one's knowledge & ability.
  (xii) Take full professional responsibility for own work

4. Application Procedure

A notice calling for applications to sit the Accreditation Program will be issued each year by the Accreditation Panel and can be found on the ACPSEM website (http://www.acpsem.org.au). The notice will indicate the closing date and the application fee. Applications received after the closing date will be accepted at the discretion of the Chairman of the Professional Standards Board. Additional calls for applications may be made at the discretion of the Chairman of the Professional Standards Board.

A fee is required for accreditation, payable upon application. This fee has been set to partly recover some of the costs associated with the conduct of the assessment. The fee will be determined by Council each year. Details of the fee will be specified in the notice calling for applications.

No candidate shall sit for any of the examination procedures until the appropriate fee has been paid.

[2] Based in part on the IPEM's definition of a professional physicist.

Applications shall be made in writing and forwarded to:-

The General Manager
ACPSEM Office
Suite 3.13 Aero247
247 Coward St
Mascot NSW 2020
Australia

Ph:- 61 - 2 – 9700 8522
Fax:- 61- 2-9693 5145
Email:- admin@acpsem.org.au

prior to the closing date for applications.

Applications shall include:-

- A completed application form (Refer to Appendix A) including the names and addresses of two medical physicists in radiation oncology who are prepared to attest to the candidate's professional capabilities and experienced gained in radiation oncology medical physics. At least one of these physicists should be accredited in Radiotherapy Equipment Commissioning and Quality Assurance.
- A detailed curriculum vitae containing information on past professional experience in the relevant areas of radiation oncology medical physics including a list of publications, internal reports or other documents relating to radiotherapy equipment commissioning and quality assurance. The applicant should indicate if they have maintained a logbook or workbook and the level of detail of their activities contained in such books.
- A signed statement from the Chief Physicist of the Department in which the candidate is working, attesting to the accuracy of the information provided by the candidate and that, in their opinion, the applicant will be able to demonstrate the knowledge and competencies required by the Accreditation Program.

Applications will only be considered when all the requested information has been provided by the applicant. The Accreditation Panel may request the provision of additional information or documentation such as copies of reports or other documentation listed in the applicants' curriculum vitae.

5. Accreditation Assessment

The accreditation assessment involves four sections. They are:

(i) a review of professional experience (via documentation)
(ii) a written examination
(iii) a practical examination
(iv) a general oral examination.

No precise examination mark shall be given for the examinations but a relative weighting for the written examination will be approximately 30% whilst the practical/oral examination will be approximately 70%. A pass in the practical examination is mandatory but this will not be finally assessed until the candidate has completed the general oral examination.

Assessment of Professional Experience

The Accreditation Panel will assess the information provided in the application. The Chairman of the Accreditation Panel may request further information or advise that additional experience is required before proceeding to the examination stage.

As a minimum requirement, the candidate shall have experience with:

(i) megavoltage x-rays
(ii) megavoltage electrons
(iii) low energy x-rays.
(iv) protection from Photons and Neutrons

This will include substantial experience in commissioning and quality assurance of radiotherapy equipment existing over a period of at least three and a half years. The depth of experience and knowledge shall be sufficient to satisfy the requirements of any of the examinable material in the written and practical examination.

Experience with low energy x-ray units must include sufficient experience to measure the radiation output and half-value-thickness for a superficial and/or orthovoltage treatment machine.

Further experience may be obtained at another radiotherapy centre.

After the submitted documentation has been approved by the Accreditation Panel, the applicant will be advised that their application has been accepted and the dates and arrangements for the subsequent examinations.

If the candidate's experience is considered to be insufficient by the Accreditation Panel, the candidate shall be so notified, and may reapply for accreditation without payment of an additional fee when the indicated experience deficiencies have been addressed.

Candidates who decide to withdraw their application after it has been accepted or defer sitting for the written or practical examinations must advise the Chairman of the Accreditation Panel in writing.

Written Examination

All candidates will be required to sit for a written examination. The arrangements for this examination shall be organised at the discretion of the Accreditation Panel with appropriate supervision organised for the applicant to carry out the exam locally.

Questions shall be derived from the attached syllabus (Appendix B). The examination will be carried out under "open-book" conditions. The questions may be either theoretical or practical in nature, but the overall aim of the examination will be to relate the candidate's answers to the practical aspects of commissioning and quality assurance of radiotherapy equipment. Hand written notes may not be taken into the written examination. Computers may not be used in the written examination without special prior approval from the Chairman of the Accreditation Panel.

The written examination shall be held at a date early enough to provide sufficient time to mark the candidate's paper before the practical and general oral examinations are undertaken.

A candidate must pass the written examination before proceeding to the practical and oral examinations.

Example written examination questions are given in Appendix C.

Candidates who have deferred sitting the written examination must advise the Chairman of the Accreditation Panel in writing, by the due date for applications in a given year, that they wish to sit the written examination in that year.

Practical Examination

A pass in the practical examination is mandatory for accreditation.

The Chairman of the Accreditation Panel shall appoint examiners (from the Accreditation Panel) to the Examination Panel who will conduct the examination. One of the examiners will act as Chairman of the Examination Panel. A maximum of two trainee examiners may also be present.

The practical examination shall comprise of two assignments. The candidate shall be advised of the assignments at least 20 minutes before the commencement of the first assignments and shall be given at least 15 minutes after the first assignment before embarking on the second assignment. Candidates may make notes during the preparation period for use when carrying out the assignment.

The assignments shall involve tasks, which will require approximately 30 to 90 minutes each to complete with a total time of approximately 2.5 hours. The progress of the work during this time shall be the responsibility of the Chairman of the Examination Panel.

Examples of assignments topics, which may be chosen, are listed in Appendix D.

The examiners may ask questions during the practical examination but these interruptions will be limited to points of immediate and pertinent concern at the time. General questions on the practical examination shall be asked at the end of the practical examination and during the general oral examination.

The candidate shall not be expected to have a detailed knowledge of the specific equipment, which he/she is asked to use to carry out the practical examination. A person who is familiar with the equipment in the department where the examination is being held will operate the equipment for the candidate if required. This person will act as a “technician” only.

If time is limited, the Chairman of the Examination Panel shall ask the candidate to delete some aspects of the procedure in which he/she is being examined. This shall be at the discretion of the Chairman of the Examination Panel.

During the practical examination, candidates will be expected to demonstrate:-

- (i) a broad understanding of the task
- (ii) the theoretical aspects relating to the task
- (iii) the practical aspects of undertaking the task (including proficiency in completing task)
- (iv) interpreting the data (including a knowledge of relevant standards or expected results) and its applicability to other aspects such as planning or treatment
- (v) a clear understanding of the processes involved
- (vi) the ability to clearly & logically explain the work as it is undertaken and by satisfactorily answering questions during the assigment

Candidates will be provided with any data required to complete each assignment. Candidates may take hand written notes or other documentation into the practical examination. However, candidates will, in general, not have time to make extensive use of such material. Candidates are expected to be able to carry out the assignments proficiently. The Chairman of the Examination Panel reserves the right to review any documentation brought to the practical examination by the candidate.

Candidates should describe to the examiners what they are doing as they carry out the assignments. They must clearly indicate what assumptions they would like to make. The Chairman of the Examination Panel will decide if the candidate will be allowed to make such assumptions.

The examiners will make written notes during the practical examination.

The timing and siting of the practical and oral examinations will be based on the following :

- (i) the availability of examiners from the Accreditation Panel
- (ii) a minimum of two and a maximum of four candidates to examine
- (iii) access to equipment in a radiation oncology department
- (iv) availability of individuals willing to operate the equipment
- (v) the distribution of home addresses of the candidates

If practicable, practical and oral examinations will be held on the week-end prior to the Annual Conference on the Engineering and Physical Sciences and in Medicine. Additional practical and oral examinations will be held at the discretion of the Accreditation Panel.

It will be the candidate's responsibility to arrange all expenses necessary to attend the examination.

Demand of this Accreditation Program has meant that there are often more candidates waiting to sit the practical examination than can be examined in one year. In such cases, a practical examination queue will be created. The initial position of a candidate in this queue will be determined by the date that their accreditation application was received. Candidates who are allocated a place in a practical examination in a given year but who are unable to attend may be placed at the end of the queue.

Candidates who have deferred sitting the practical examination will be removed from the practical examination queue. Such candidates will be placed at the end of the queue when they have advised the Chairman of the Accreditation Panel in writing that they wish to sit practical examination.

General Oral Examination

The final oral examination shall involve the candidate answering specific questions during a period of approximately 30 to 60 minutes.

This oral examination is to enable the examiners complete their assessment on whether the candidate may be accredited. Questions may be asked on:-

(i) the written examination.
(ii) the two cases examined during the practical.
(iii) details submitted in the curriculum vitae, reports and publications.
(iv) other areas related to radiotherapy equipment commissioning and quality assurance.

The Decision

After the oral examination, the examiners shall decide whether the candidate will be awarded a pass or a fail. A pass will be awarded if the examiners are satisfied that the candidate can competently and safely undertake the work within the scope of the Accreditation Program without supervision.

The Chairman of the Examination Panel shall prepare a report and forward it to the Chairman of the Professional Standards Board.

Chairman of the Professional Standards Board shall advise the candidate in writing of the result of the assessment.

Enquiries from candidates regarding their assessment should be directed to the Chairman of the Professional Standards Board.

Any further discussion or consideration of the result of the accreditation shall not proceed any further without the specific approval of the Chairman of the Professional Standards Board. In extraordinary circumstances, the Council of the ACPSEM may request further information on the result of the candidate's assessment.

In certain circumstances, where it is considered that a candidate has a significant deficiency of knowledge or skill, but that deficiency does not warrant awarding a failure, then the candidate may be requested to perform supplementary work. In this case, the accreditation result will be withheld until the supplementary work has been completed and examined. The supplementary work may consist of (but will not be limited to) the preparation of a report on specified topics or the completion of practical work in the presence of an examiner or an accredited physicist. The Chairman of the Examination Panel will assign one examiner the responsibility for assessing the supplementary work. The candidate will be required to complete the supplementary work within a specified time (i.e they will be given a due date). The candidate may only contact the

Chairman of the Examination Panel to clarify the scope of the supplementary work. The examiner will assess the supplementary work within 4 weeks of the due date and advise the Chairman of the Examination Panel.

Failure

Candidates who fail any part of the examination and who wish to re-sit the examination may do so under the conditions given below and shall pay an additional repeat examination fee. This is in accordance with the following policy adopted by the ACPSEM Council in 2000 regarding repeat examinations:

(i) A candidate who fails the accreditation examination on the first attempt will be guaranteed a place in the following year provided that within 8 weeks of the notification of failure they indicate an intention to re-sit the exam and forward a a non refundable deposit[3] towards the examination fee. Otherwise the candidate may submit an intention to re-sit at anytime, but they will be placed in a queue along with other applicants based on the time of receipt of the intention. In such case, a place will not be given for the next exam if there is already a full quota of applicants.

(ii) A candidate who fails the examination on the first attempt, and is not re-examined within two examination periods[4], must apply afresh and be examined in all components.

(iii) A candidate, who fails the examination a second time, within 2 examination periods of the first attempt, may not apply again for 12 months and must apply afresh and be examined in all components.

(iv) The re-examination fee will be 100% of the initial examination fee applicable in the year in which the candidate re-sits the examination if all components are examined, 33% for the written part only and 75% if either or both the practical or oral component is examined.

Appeal

A candidate who has been awarded a fail may lodge an appeal. An appeal may only be based on the grounds of due process or matters of fact. An appeal must be lodged in writing with the Chairman of the Professional Standards Board.

[3] The dollar value of the deposit is given in the most recent call for applications to sit the accreditation.
[4] Note that examination periods are used rather than years because examinations are not held exactly every 12 months.

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Appendix A – Application Form

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Application Form for Accreditation in Radiotherapy Equipment Commissioning & Quality Assurance

Personal Details

Name ……………………………………………………………………………………….
Address: ....…………………………………………………………
......................................…………………………………………………………
......................................…………………………………………………………
Postcode: ....

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

Email: ………………………………………………………………………………………..

Current position title: ....……………………………………………………………

full-time ☐ part-time ☐ hours/week in RO ……..

Department: ……………………………………………………………………………….
Address: ……………………………………………………………………………….
………………………………………………………………………………
………………………………………………………………………………

Telephone: ………………………………….
Fax: ………………………………….
Email: .……………………………….

Qualifications: …………………………………………………

How many years full-time equivalent work in radiation oncology (list time at each institutions):
………………………………………………………………………………………………..
………………………………………………………………………………………………..
………………………………………………………………………………………………..
………………………………………………………………………………………………..
………………………………………………………………………………………………..

Provide the names, addresses, email, phone and fax numbers for two professional referees who can verify the information provided in this application.

Referee 1:

Name ……………………………………………………………………………….
Address: ……………………………………………………………………………….
……………………………………………………………………………….
……………………………………………………………………………….
Postcode: ....

Telephone: ……………………………….
Fax: ………………………………….
Email: ……………………………….

Referee 2:

Name …………………………………………………………………………………….
Address: …………………………………………………………………………………….
…………………………………………………………………………………….
…………………………………………………………………………………….
Postcode: ....
Telephone: ………………………………….
Fax: ………………………………….
Email: ……………………………….

Your contact address (if different from above):

Address: ....……………………………………………………………
....……………………………………………………………
....……………………………………………………………
Postcode: ....

Formal Course Attendance

Please list details of courses attended whose content is relevant to this Accreditation Program.

Courses attended	*Dates*	*Qualification obtained*

……………………………………………………………………………………………….
……………………………………………………………………………………………….
……………………………………………………………………………………………….
……………………………………………………………………………………………….

Please attached copies of the course outlines/syllabus.

Summary of Experience

Please indicate your level of experience using the following coding system for each of the listed activities:-

0 No experience
1 Partial experience performing work with existing procedures under supervision
2 Comprehensive experience performing work with existing procedures under supervision
3 Comprehensive experience performing work with no supervision
4 Design & implementation of selected, procedures, equipment & other tools
5 Design & implement work program
6 Supervise work program

It may be necessary to select multiple codes for each area of work. Please provide supporting evidence for the selected codes in your CV.

Linear Accelerators

	Circle one or more codes
Radiation shielding design for room	0 1 2 3 4 5 6
Absolute calibration	0 1 2 3 4 5 6
Radiation survey Neutron issues included? Yes / No	0 1 2 3 4 5 6
Acceptance & performance tests	0 1 2 3 4 5 6
Data acquisition	0 1 2 3 4 5 6
On-going quality assurance	0 1 2 3 4 5 6

X-ray beam energies ………………………………………………. (list energies)
Electron beam energy ………………………………………………. (list energies)

Superficial Therapy X-ray Unit

Radiation shielding design for room	0 1 2 3 4 5 6
Absolute calibration	0 1 2 3 4 5 6
Radiation survey	0 1 2 3 4 5 6
Acceptance tests	0 1 2 3 4 5 6
On-going quality assurance	0 1 2 3 4 5 6
Data acquisition	0 1 2 3 4 5 6

X-ray beam energies ………………………………………………. (list energies)

Orthovoltage Therapy X-ray Unit

Radiation shielding design for room	0 1 2 3 4 5 6
Absolute calibration	0 1 2 3 4 5 6
Radiation survey	0 1 2 3 4 5 6
Acceptance & performance tests	0 1 2 3 4 5 6
On-going quality assurance	0 1 2 3 4 5 6
Data acquisition	0 1 2 3 4 5 6

X-ray beam energies ………………………………………………. (list energies)

Simulator

Radiation shielding design for room	0 1 2 3 4 5 6
Radiation survey	0 1 2 3 4 5 6
Acceptance & performance tests	0 1 2 3 4 5 6
On-going quality assurance	0 1 2 3 4 5 6

CT option included? Yes / No

CT scanner

Radiation shielding design for room	0 1 2 3 4 5 6
Radiation survey	0 1 2 3 4 5 6
Acceptance & performance tests (including CT number calibration)	0 1 2 3 4 5 6
On-going quality assurance (including transfer of images to TPS)	0 1 2 3 4 5 6

Note that your should also provide a reasonable detailed description of your experience in external beam treatment planning in your CV.

Signature: ………………………………………….

Date: ….. /….. / ……….

Certification by Chief Physicist:

I agree that, to the best of my knowledge, the accuracy of the information provided by the applicant is correct and that in my opinion the applicant will be able to demonstrate the knowledge and competencies required by the Accreditation Program.

Name: …………………………………………………………

Position: …………………………………………………………

Signature: ………………………………………….

Date: ….. /….. / ……….

Appendix B –Syllabus & Recommended Reading List

The reference material contained in this appendix consists of text books, journal articles, NCRP reports, AAPM reports & monographs, IPEM reports, ICRU reports, ICRP Reports, IEC Standards, Australian Standards and other documents. While every effort has been made to provide a list of references for the candidates to read to prepare for the written exam, the references may not cover all the topics included in the syllabus. It is the responsibility of the candidate to ensure that they have adequately studied all aspects of the topics in the syllabus. The reference list may change from time to time. The text books and journal articles chosen to be included in the reference list does not imply that these documents are the only ones that contain the relevant material. The candidate should use reference material not included here.

Note that this Appendix is currently under revision and will be updated by 31/3/05. References for areas to be added to the scope of the Accreditation Program from 1st January 2006 have already been included.

Suggestions from candidates regarding references are always welcome!!

SECTION 1: RADIATION PHYSICS

REFERENCES

This section is intended as a brief review of the basic physics which forms a background to several of the other sections. The content of the references listed indicates the depth of knowledge required. Candidates are expected to be able to apply this knowledge to answer questions of practical significance.

Book and Sections
See p30 for Reference List.

1.1.	**Matter and Energy**	
1.1.1.	Structure of matter - Atoms, nuclei, elemental particles. Atomic and nuclear structure and energy states.	Ref 1, Sections 1.03 - 1.08 Ref 12 Chapter 1
1.1.2.	Electromagnetic radiation Electromagnetic waves and quanta. $E=h\upsilon$ The electromagnetic spectrum Radiation of photons from atoms	Ref 1, Sections 1.09 - 1.12 Ref 12 Chapter 3
1.2.	**Production of X-rays**	
1.2.1.	X-ray spectra	Ref 1, Section 2.07 Ref 12 Chapter 3
1.2.2.	Electron interactions with the target. Ionisation collisions. Radiative collisions. Mechanisms of production of bremsstrahlung and characteristic radiation. Dependence of X-ray intensity on energy of bombarding electrons.	Ref 1, Sections 2.08 - 2.10 Ref 12 Chapter 3
1.2.3.	Angular distribution of X-rays	Ref 1, Section 2.11
1.3.	**Radioactivity**	
1.3.1.	Natural and artificial radioactivity	Ref 1, Sections 3.01 - 3.02
1.3.2.	Modes of decay: α, β, γ, electron capture. Decay scheme for cobalt-60. Physical characteristics of the emissions. Exponential decay, half-life, transformation (decay) constant.	Ref 1, pp 82-83 Ref 12 Chapter 2
1.3.3.	Activity and its units (Bq, Ci)	Ref 1, Section 3.03 Ref 12 Chapter 2
1.4.	**Interactions of X-rays and gamma rays with matter**	
1.4.1.	Processes that occur when a beam of X-rays interacts with matter, leading to biological damage in tissue	Ref 1, Section 5.01 Ref 12 Chapter 5
1.4.2.	Exponential attenuation of narrow beams, linear attenuation coefficient, HVL, equivalent photon energy.	Ref 1, Sections 5.02 – 5.03 Ref 1, 8.04
1.4.3.	Broad-beam attenuation; photon build-up factor	Ref 1, Section 5.04
1.4.4.	Mass, electronic, and atomic attenuation coefficients	Ref 1, Section 5.05
1.4.5.	Energy transfer and absorption and their coefficients	Ref 1, Section 5.06
1.4.6.	Photoelectric absorption, coherent and Compton scattering, pair production: mechanisms; coefficients and their variation with photon energy, atomic number and electron density.	Ref 1, Sections 5.07 - 5.10
1.4.7	Total attenuation, energy transfer and absorption coefficients, and their variation with photon energy in water	Ref 1, Sections 5.11 - 5.12

	and in shielding and filtering materials.	
1.1.1.	The relative importance of the different interaction processes in water as a function of photon energy.	Ref 1, Section 5.13

1.5. Interactions of electrons with matter

1.5.1.	Energy losses by ionisation and radiation	Ref 1, Section 6.12
1.5.2.	Electron range and bremsstrahlung yield	Ref 1, Section 6.13
1.5.3.		

1.6. Radiation quantities and units

Fluence (m^{-1}), energy fluence (Jm^{-2}), kerma and absorbed dose (Gy, rad), exposure (C kg^{-1}, R), dose equivalent (Sv, rem)	Ref 1, Sections 1.02, 7.01, 7.02, 7.07 & 15.02 Ref 3 Ref 4 Ref 54, Sections 2.1-2.7

SECTION 2: RADIATION DOSIMETRY

2.1.	Instrumentation	Ref 53, Sections 3.1-3.2 Ref 54 Sections 3.1-3.2 Ref 55 Chapter 11
2.1.1.	Ionisation chambers & electrometers	
Practical ion chambers; construction and use Typical circuits for practical use of ion chambers Bragg-Gray cavity and determination of absorbed dose		Ref 1, Sections 7.01-7.09, 9.05--9.07 Ref 12, Chapter 6, Sections 8.1-8.6 Ref 53, Sections 3.4-3.6. Ref 54 Sections 2.8, 3.3
2.1.2.	Film	Ref 1, Section 9.11 Ref 2, Chapter 4, 2.3 Ref 12, pp172-4 Ref 51, Section 19.7
2.1.3.	Diodes	Ref 1, Section 9.08 Ref 2, Chapter 4, 2.2 Ref 51, Section 19.5 Ref 71 Ref 72
2.1.4.	Survey meters	Ref 54, Sections 4.1-4.3 Ref 12, Section 16.8 Ref 16, Chapter 6
2.2.	Absolute Dose Determination	
X-ray machines with generating voltages <150 kVp X-ray machines with generating voltages 150-300 kVp Linear accelerators (x-ray & electron beams) Cobalt units		Ref 54, Chapter 9 Ref 5 Ref 19 Ref 19a Ref 19b Ref 20
2.3.	Relative Dosimetry	To be completed
2.4.	Phantoms	Ref 53, Section 3.3 Ref 15, Section 5.5 Ref 51, Section 19.3 Ref 10 See also dosimetry protocols

SECTION 3: RADIATION ONCOLOGY TECHNOLOGY

3.1.	Linear Accelerators	Ref 7 Ref 12, Section 4.3 Ref 21 Ref 22 Ref 11, Sections 5.1-5.2, Chapter 6, Sections 7.4-7.6 Ref 82
3.2.	Kilovoltage Therapy X-ray Units	Ref 51 Sections 9.1 – 9.3 Ref 1 Chapter 2 Ref 52 Sections 2.1 – 2.5
3.3.	Simulators (including CT option)	See also previous section. Ref 51 Sections 4.1-4.4 Ref 1 Sections 16.01-16.07 Ref 8, Chapters 1, 2, 4, 5 Ref 11, Section 8.8 Ref 36, pp179-206
3.4.	CT Simulators	Ref 51 Sections 6.1-6.5 Sections 5.1-5.8 Ref 52 Section 10.3 Ref 34
3.5.	Treatment Planning System	Physics manual for TPS
3.6.	Teletherapy Radionuclide Units	Ref 1, Section 4.06 Ref 2, Chapter 4

SECTION 4: **EXTERNAL BEAM TREATMENT PLANNING**

4.1. X-ray Beam Parameters & Characteristics for Kilovoltage & Megavoltage Beams	
4.1.1. Beam quality specification	Ref 1 Section 8.01 to 8.06 Ref 12, Chapter 7
HVL, DD at 10 cm, nominal kV/MV & DD or TMR ratios	Ref 19 Ref 19b
4.1.2. Central axis beam parameters	
Percent depth dose, Peak Scatter Factor, Tissue-Air Ratio, Tissue-Phantom Ratio, Tissue-Maximum Ratio, Appropriate scatter derivatives, Equivalent squares and circles	Ref 42 Ref 12, Chapters 9 & 10
Variation with energy, field size & shape and source to surface distance	
4.1.3. Output factors in air and water	Ref 12, Sections 10.1A
Collimator & phantom scatter, collimator exchange effect for MV beams.	Ref 56 Ref 57 Ref 58
Variation with energy, field size & shape and source to surface distance	Ref 63 Ref 64
BSF & loss of backscatter for kV beams	Ref 5 Ref 60 Ref 61
4.1.4. Beam Profiles & isodose curves	Ref 1, Sections 10.11-10.14 Ref 2, Section 4.7
Off-axis ratios or similar, penumbra, factors that affect the beam profile (e.g. beam quality)	Ref 53 Section 4.6 Ref 54 Sections 6.9 -6.10 Ref 59
Variation with energy, field size & shape and source to surface distance	Need better references especially for kV beams
4.1.5. Beam modifiers	Ref 12, Section 11.4
Wedges – dynamic, physical & motorised	Ref 65 Ref 66
Wedge factors, depth dose, beam profiles Variation with energy, wedge angle and field size	Ref 67 Ref 68
	Ref 12 Section 12.5 Ref 11, Section 7.8
Bolus and compensating filters	Ref 70
4.1.6. Beam shaping	Ref 12 Section 13.1 – 13.2
Blocks, circular collimators, MLCs	Ref 58 Ref 45 Ref 46 Ref 47

	Ref 48 Ref 69
kV beams	Ref 62
Asymmetric collimators	Ref 14 Ref 14a
Output factors, beam profiles, junctions	Ref 14b
4.1.7. Rotation Therapy	Ref 1, Section 12.08 Ref 13 Section 5.4.2
4.2. Electron Beam Parameters & Characteristics for Megavoltage Beams	
4.2.1. Beam quality specification	
Nominal MeV, $\overline{E_o}$, $E_{p,0}$	Ref 15, Sections 2.2 & 2.3 Ref 76, Section 3.3
4.2.2. Central axis parameters	
Ranges, therapeutic range, R50, Rp, x-ray contamination dose. Variation with energy, applicator, insert size & shape and source to surface distance	Ref 15, Sections 6.3 – 6.3.4 Ref 76, Section 6.4 Ref 73 Ref 75, Section V
4.2.3. Beam profiles & isodose curves	
Variation with energy, applicator, insert size & shape and source to surface distance	Ref 76, Section 6.5 Ref 15, Sections 6.4-6.4.3 Ref 74
4.2.4. Output factors	
Variation with energy, applicator, insert size & shape and source to surface distance	Ref 12, Section 14.4D Ref 15, Section 5.6 - 5.7 Ref 75 Sections VII – VIII Ref 77
4.2.5. Beam shaping	
Material, thickness, position & problems	Ref 15, Section 6.3.7 Ref 75 Section IX
4.2.6. Bolus & other issues	
Penumbra wedges, bolus materials, effect of air gaps etc	To be completed
4.3. MU calculations	
MV x-rays, MeV electrons Treatment time calculations for kV x-rays	To be completed
4.4. Patient Immobilisation	Ref 51 Chapter 3

SECTION 5: RADIATION PROTECTION IN COMMISSIONING OF RADIATION ONCOLOGY EQUIPMENT

5.1.	Radiation exposure, effects & risks	Ref 17, Section 3
Background radiation, data from atomic bob survivors, and radiation accidents, exposure types		
5.2.	Quantities & units used in radiation protection	
Dose equivalent, Sievert, rem, quality factors, modifying factors		Ref 17, Section 2 Ref 16, pp 42-46 Ref 1, Section 15.02 Ref 18
5.3.	Principles and basic framework of radiation safety and protection standards	Ref 17, Sections 4-5 Ref 96
Justification, optimisation, limitation, maximum permissible doses, occupational and non-occupational dose limits, tissues at risk, critical organs, ALARA principle, international standards		Ref 16, Chapter 5 Ref 30a
5.4.	National/state regulations and standards on radiation safety	Ref 30 Ref 97 State Radiation Safety Act & Regulations
5.5.	Cost benefit analysis	Ref 49 Ref 50
5.6.	Operational Radiation Safety Program	Ref 16, Chapter 9
Facility requirements staff responsibilities, personnel monitoring, safe work practices, emergency procedures, incident reporting, equipment management, auditing, record keeping		
5.7.	Facility design	
Controlled versus non-controlled areas		Ref 54 section 16.10.3 & 16.17 Ref 81 Ipem report State Regulations
5.8.	Structural shielding design	
5.8.1.	Linear accelerators and radionuclide teletherapy units	Ref 86, Chapters 1
5.8.1.1.	Primary barriers - workload, use, occupancy factor and distance factors	Ref 86, Chapters 2 Ref 1, Section 15.05 Ref 17
5.8.1.2.	Secondary barriers - scatter, leakage	Ref 86, Chapters 2 Ref 1, Section 15.06 -

		15.07 Ref 12, pp 402 – 403 Ref 27 Ref 31 pp10,57
5.8.1.3.	Maze and other issues	Ref 86, Chapters 3 – 7 Ref 29 Ref 89
5.8.2.	Kilovoltage therapy x-ray uints	Ref 28
5.8.3.	Simulators	Ref 88 Ref 28 Ref 86, Chapters 1-4
5.8.4.	Construction & Materials	To be completed
5.8.5.		
5.8.6.	CT scanners	Ref 86, Section 6.5, Chapter 4
5.9.	Safe work practices and emergency procedures	State regulations and local procedures Ref 78 Ref 98 Ref 83
5.10.	Unplanned exposures and other radiation incidents	State regulations and local procedures Ref 54, Section16.16 Ref 78 Ref 96 Ref 83
5.11.	Personnel monitoring	
Film badge, TLD, pocket ionisation chambers, personnel neutron monitors		Ref 12 Chapter 8 Ref 16, Chapter 7

SECTION 6: COMMISSIONING AND QUALITY ASSURANCE PROCEDURES FOR RADIATION ONOLOGY EQUIPMENT

6.1.	General	Ref 51 Chapter 2 Ref 6 Ref 26
6.2.	Radiation Safety Assessment of Facilities	State Radiation Safety Act & Regulations
Measurement of low dose rates in radiation surveys, confirmation of protection levels, verification of other engineering controls.		Ref 86, Chapter 9 Ref 88, Chapter5 Ref 25, Chapter 2 Ref 23 Ref 37 Section 8
6.3.	Linear Accelerators	
6.3.1.	Performance Standards	Ref 24 Ref 80
6.3.2.	Safety, Performance & QA Tests	Ref 6 Ref 2 Chapter 5 Ref 12 Chapter 17 Ref 25, Chapters 1, 3, 5
6.3.3.	Commissioning Procedures	Ref 6 Ref 27 Ref 25, Chapter 4
6.4.	Kilovoltage therapy x-ray units	
6.4.1.	Performance Standards	Ref 92
6.4.2.	Safety, Performance & QA Tests	Ref 6 Ref 2, Chapter 6 – Section 7 Ref 51, Sections 9.4.1, 9.4.3 & 9.5.3
6.4.3.	Commissioning Procedures	Ref 2, Chapter 6 – Sections 4 & 6 Ref 51, Sections 9.4.2 & 9.5.2
6.5.	Simulators	
6.5.1.	Performance Standards	Ref 41 Ref 79 Ref 93 Ref 94
6.5.2.	Safety, Performance & QA Tests	Ref 6 Ref 9

		Ref 39 Ref 51, Section 4.9
6.6.	CT Simulators	
6.6.1.	Performance Standards	Ref 91 Ref 85
6.6.2.	Safety, Performance & QA Tests	Ref 66 Ref 38
6.6.3.	Commissioning Procedures	Ref 66 Ref 33 Ref 35
6.7.	Physics Equipment	
6.7.1.	Performance Standards	Ref 84 Ref 95
6.7.2.	Performance & QA Tests	
Ionisation chambers, electrometers, beam data acquisition systems, film densitimeters, film, diodes		Ref 6 Ref 26 Ref 90

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Appendix C – Sample Written Exam Questions

SECTION 1

EXAMPLE 1

(a) State briefly how each of the following varies with the energy of the electrons striking the target in a medical linear accelerator operating in the x-ray mode:

(i) the efficiency of x-ray production

(ii) the angular distribution of intensity of the emitted radiation

(b) State how the mass attenuation coefficient varies with photon energy for the three main attenuation processes of interest in radiotherapy.

(c) Which of these processes predominates in the brass beam flattening filter of a 4MV linac ?

(d) If the energy of the electrons incident on the (thick) target of a 4MV linac fitted with a brass flattening filter increased, (all other operating parameters remaining the same), what effect would you expect on:

(i) dose rate, (assume any servo control is disabled)
(ii) depth of dose maximum in a water phantom
(iii) beam profile in a principal plane at the depth of dose maximum
(iv) dose per monitor unit at the depth of dose maximum on the central axis
(v) dose per monitor unit at the standard calibration point, (assume this to be at a depth of 5cm)

Give a brief explanation in each case.

EXAMPLE 2

(a) Describe the processes by which a high-speed electron may lose its energy when it impinges on a metallic target.

(b) How does the proportion of energy dissipated in these various processes change as the energy of the electrons incident on a target increases?

(c) Explain qualitatively the shape of the spectrum of x-rays which constitute the beam emerging from an x-ray therapy unit.

(d) Explain why a flattening filter is required for a linear accelerator producing a clinical photon beam, but usually not for a ^{60}Co unit or an orthovoltage unit.

(e) Explain why a variation in average photon energy with distance from the beam axis would be expected for a 4 MV x-ray beam.

SECTION 2

The Secondary Standard dosimeter has just been returned to you following calibration at the appropriate National Standards Laboratory.

(a) What checking would you carry out before using it to calibrate other dosimeters?

(b) Describe the practical steps necessary to transfer the calibration factors from the Secondary Standard to field instruments for routine use.

SECTION 3

<u>EXAMPLE 1</u>

(a) Write short notes on the type of detector and experimental arrangement you would consider suitable for the following measurements:

- (i) Exposure rate measurements for an Orthovoltage therapy machine (140 - 300 kVp).
- (ii) Half Value Thickness measurement of a Simulator beam at 120 kVp. State the approximate H.V.T. you would expect to get.
- (iii) Photon leakage around the 'head' of a 6MV Linear Accelerator

(b) You have made percentage depth dose measurements on a megavoltage photon beam and consider that the energy is too low by a small amount. How would you go about altering the energy, and why?

(c) Describe how you would go about measuring the energy of 8 MeV and 18 MeV electron beams. Describe in general terms the differences you would expect to see between the two beams.

<u>EXAMPLE 2</u>

An ionisation chamber is to be used to make output and central axis depth dose measurements on a linear accelerator which produces 4MV x-rays and electrons with energies 5-15 MeV.

(a) Describe the set-up used to determine the output dose rate, and list the correction factors necessary to convert the dosimeter reading to absorbed dose for -

- (i) 4 MV x-rays
- (ii) 15 MeV electrons

(b) Explain how you would determine the collection efficiency of the ionisation chamber when used in a pulsed electron beam.

(c) When the ionisation chamber is used in a water phantom to determine central axis depth doses for an electron beam, what other additional corrections have to be made?

SECTION 4

EXAMPLE 1

(a) (i) Describe how you would go about a routine 'flatness' measurement on a photon beam from a linear accelerator. State the limits you consider acceptable.

(ii) Describe a method for measuring Tissue Phantom Ratios for a megavoltage photon beam.

(b) Describe how you would go about measuring a set of 'Off Axis' photon data that would be suitable for your Hospital's planning computer; if your Hospital does not own one than you may choose any commercially available system.

In either case, state the type of computer being considered.

EXAMPLE 2

(a) Write short notes on the type of detector(s) and experimental arrangement you would consider suitable for the following measurements.

(i) Exposure rate measurements for a range of superficial half value layers (20-100 kVp)

(ii) Photon leakage around the head of a ^{60}Co Unit

(b) For reasons of convenience, you have decided to make some 6MV photon beam measurements in a Perspex (P.M.M.A.) phantom. Holes have been predrilled to accept a 0.6cc 'Farmer' chamber and all the holes are beyond the build up region. Describe what factors you would need to measure/look up in order to convert the absorbed dose in perspex to dose in water.

SECTION 5

Discuss the various phantom materials which may be used for electron dosimetry. How do the measurements at a depth compare for these different materials?

SECTION 6

EXAMPLE 1

A 6MV x-ray linear accelerator is to be installed into an extension built onto the Radiotherapy Department, in an area currently used as a carpark. Building constraints limit the outside dimensions of this single storey room to 10 x 9 metres. Adjacent to each of the four sides of this area will be (i) outpatient clinic, (ii) corridor, (iii) and (iv) carpark.

Estimated maximum annual workload = 5.0 x 10^4 Gy/yr at isocentre.

(a) Sketch the layout you would propose for this installation, giving reasons for your choice of position and orientation of the linac.

(b) Calculate the required thickness of the primary barriers for this layout, stating clearly the occupancy and use factors used. (NOTE: Assume the barriers are to be of concrete for which the Tenth Value Layer at this energy is 0.35m).

EXAMPLE 2

You are provided with a floor plan of an existing COBALT-60 installation. It is proposed to install a 4MV linear accelerator in this room as a replacement for the cobalt unit.

Discuss the design modifications you would make to this room in order to comply with the requirements of the Code of Practice.

Discuss briefly what verification measurements for Radiation Protection you would carry out after installation is complete.

Appendix D – Example Practical Exam Questions

LINEAR ACCELERATORS

1. Carry out an initial safety assessment on a linear accelerator.

2. Perform a radiation protection survey of the external area surrounding a treatment room housing a linear accelerator.

3. Perform a radiation protection survey within the treatment room housing a linear accelerator.

4. Find the mechanical isocentre shape and size.

5. Test the agreement of x-ray and optical system.

6. Check the laser alignment.

7. Check the optical system (excluding lasers).

8. Check the angle scales on gantry, collimator and couch.

9. Test the accuracy of the couch movement.

10. Test the collimators.

11. Set up the water tank and carry out one of the following:

    (i) Measure flatness and symmetry for the x-ray or electron beam.

    (ii) Measure central axis per cent depth dose for the x-ray or electron beam

    (iii) Measure beam profiles, central axis per cent depth dose and wedge angle for a wedged x-ray beam

    (iv) Measure beam energy for the x-ray or electron beam

    (v) Measure tissue phantom ratios or tissue maximum ratios for an x-ray beam

    (vi) Measure field size factors for an x-ray or electron beam

    (vii) Measure the transmission factors through an absorber for the x-ray or electron beam

    (viii) Measure the effect of distance on the dose per monitor unit for an x-ray or electron beam

    (ix) Measure the electron beam characteristics.

12. Calibrate the linear accelerator for x-rays.

13. Calibrate the linear accelerator for electrons.

14. Measure the wedge factors for x-rays.

15. Measure the attenuation coefficients for the x-ray beam.

16. Intercompare two given ionisation dosimeters.

17. Do consistency checks on an ionisation dosimeter.

18. Cross calibrate a cylindrical and parallel plate ionisation chamber.

19. Measure the polarity and recombination effects on an ionisation chamber.

20. Test the linearity of the accelerator dose monitor.

COBALT-60 TELETHERAPY UNIT

1. All tests analogous to those listed for linear accelerators.

2. Check timer and source movement.

3. Measure tissue-air-ratios.

SUPERFICIAL AND ORTHOVOLTAGE X-RAY UNITS (1 mm Al to 4.0 mm Cu HVL)

1. Measure output dose rates.

2. Check timer.

3. Measure HVL.

SIMULATOR X-RAY UNIT

1. Any mechanical or optical tests as listed for linear accelerators.