The Degree Programme in Clinical Technology

The Institute of Physics and Engineering in Medicine (IPEM) and the Association of Renal Technologists, on behalf of the Voluntary Register of Clinical Technologists (VRCT), have developed a degree programme in Clinical Technology to support the regulation of Clinical Technologists by the Health Professions Council (HPC). Statutory regulation requires that there is a clearly defined scope of practice for regulated professionals. This scope of practice is supported by standardised education and training, leading to regulated professionals who have protected titles that are meaningful to the public.

This document outlines the learning outcomes and indicative content for a Degree in Clinical Technology to support the scopes of practice proposed by the VRCT associated with the following protected titles:

- Medical Engineering Technologist
- Radiation Engineering Technologist
- Rehabilitation Engineering Technologist
- Renal Technologist
- Nuclear Medicine Technologist
- Radiation Physics Technologist
- Radiotherapy Physics Technologist

This provides the basis of standardised education and training that will ensure that a newly qualified clinical technologist will be able to undertake their scope of practice wherever they have trained within the United Kingdom.

This document assumes that the degree programme will delivered over 4 years part time with 360 credit points in England, Wales and Northern Ireland and 480 credit points in Scotland. The programme design, however, can easily be modified to be delivered as a full time programme. Additional foundation modules in basic science, engineering and mathematics may be required in Scotland.

Indicative credit points are shown for each subject area to give guidance as to the amount of study time that should be spent on each subject.

The clinical practice placements and clinically based project should attract 90/120 credit points in total. A minimum of 18 months whole time equivalent clinical practice/clinically based project work should be undertaken.

Education Providers must ensure in the design of their programmes that there is a stepping off point after 2 years whereby Assistant Practitioners in Clinical Technology can emerge with an appropriate Dip HE. At the same time, it must be possible to accredit prior experiential learning (APEL) so that individuals can join the programme at an appropriate point and obtain a Clinical Technology degree. Trainees with existing Physics or Engineering degrees should be able to undertake appropriate graduate diplomas to ensure that they can obtain any additional underpinning knowledge and clinical practice experience required to meet the standards required by this degree programme.

The Degree Programme in Clinical Technology

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The Degree Programme in Clinical Technology

Learning outcomes to be achieved at the end of the first 2 years of the degree programme (Dip HE level).

Core Learning Outcomes

1. Work within appropriate safety and quality standards

Anatomy and Physiology 15cp

1. Describe the structural organisation of the human body from cell to organ system using appropriate histological and anatomical terminology
2. Demonstrate an understanding of the principles of homeostasis and the role of the organ systems in its maintenance
3. Demonstrate the integrated function of the major organ systems of the human body
4. Describe and explain the roles of the cardiovascular, respiratory and renal systems in the maintenance of homeostasis e.g. cardiac output, blood pressure, respiratory gases, regulation of pH
5. Describe the importance of nervous and hormonal control of physiological systems in the maintenance of homeostasis.
6. Describe the main features of the musculo-skeletal system
7. Identify the key stages in the anatomical and physiological development of the human body
8. Explain the mode of action of sensory receptors and their role in the special senses e.g. vision, hearing, taste

Mathematics and Statistics 15cp

1. Demonstrates the appropriate use of number, algebra, trigonometry, exponential, graphs and linear relationships to solve medical problems
2. Demonstrates understanding and application of reduction to linear form, differentiation, and integration to solve medical problems
3. Demonstrates skills in the analysis and interpretation of data within a work-based context.
4. Formulate hypotheses on medical data and perform appropriate tests

Health & Safety, Research Methods & Hospital Practice 15cp

1. Demonstrate an understanding of the Health & Safety legislation associated with the clinical environment
2. Describe and explain hazards in the workplace and precautions in place to control the risk
3. Describe the Organisational structure and the context at a local and national level, including staff development and scope of practice
4. Demonstrate appropriate communication skills when dealing with patients in the workplace
5. Demonstrate an understanding of research methods, clinical governance, clinical audit, ethics and quality systems
6. Demonstrate an understanding of basic first aid and cardiopulmonary resuscitation
7. The theory and practice of management tools necessary to perform effectively within an organisation

Computers and IT 15cp

1. Describe and explain the basics of computer hardware
2. Develop a computer programme to manipulate medical information
3. Manipulate and present medical information by the use of Spreadsheet, Database and PowerPoint
4. Describe and explain the need for data security and confidentiality within the medical environment

CONTENTS

Core Learning Outcomes for Medical Engineering Technology, Rehabilitation Engineering, Radiation Engineering and Renal Technology

Engineering Technologists must understand both electronic and mechanical principles. A technologist working in Equipment Management needs to understand mechanical principles of anaesthetic equipment, for example, and Rehabilitation Engineers need to understand electronic control systems for environmental controls and wheelchair controls.

Electronics Principles 30cp

1. Understand electrical and magnetic fields
2. Demonstrate competence in the analysis and both direct current and alternating current electrical circuits.
3. Apply principles of circuit design
4. Systematically solve problems in circuit design
5. Produce a printed circuit board for a simple circuit
6. Design circuits using operational amplifiers for linear and non-linear applications;
7. Choose and apply appropriate mathematical methods to analyse circuit behaviour and describe electrical signals.

Digital systems 15cp

1. Develop competence in design techniques associated with digital logic circuits and a fundamental understanding of microprocessor architecture
2. Understand and apply electronic principles, methodology and tools in digital system design;
3. Understand and apply techniques for interfacing a range of transducers to microprocessors
4. Be able to write simple microprocessor programmes

Mechanics and Materials 15cp

1. Describe the fundamental principles of applied mechanics and basic analytical and graphical methods
2. Solve simple examples in applied mechanics
3. Describe the basic systems underlying fluid motion and fluid systems performance
4. Describe the structure, mechanical and physical properties of materials used in clinical engineering applications

CONTENTS

Core Learning Outcomes for Medical Engineering Technology, Rehabilitation Engineering and Renal Technology

Engineering Design 15cp

1. Demonstrate familiarity with sources of design information;
2. Make effective use of components in an engineering design;
3. Apply problem solving techniques to an open ended design problem;
4. Exercise judgement across a range of functions in Computer Aided Design, communication, design and manufacture
5. Present alternative solutions to an appropriate audience

Measurement and Sensors 15cp

1. Demonstrate an understanding of the source and nature of physiological signals
2. Critically evaluate the choice of transducer and equipment to measure specific physiological signals
3. Demonstrate an understanding of measurement errors, propagation of errors, calibration and tolerances
4. Undertake appropriate analysis of clinical measurement data and critically evaluate the issues of errors, tolerances and calibration that affect the outcome of the analysis

Biomechanics 15cp

1. Review and evaluate the structure and function of the musculoskeletal System
2. Describe human movement and techniques for analysing movement
3. Understand kinetics and kinematics
4. Understand thermodynamics and its application in biomechanical systems

CONTENTS

Core Learning Outcomes for Nuclear Medicine Technology, Radiation Engineering Technology, Radiation Physics Technology and Radiotherapy Physics Technology

Ionising Radiation Physics 30cp

1. Describe and explain atomic structure and the laws of radioactive decay
2. Describe and explain the production of X-rays and other sources of radiation
3. Describe and explain the interactions of radiation with matter and radiation dosimetry
4. Describe and explain the interactions of electrons with matter
5. Describe and explain basic radiation protection and dose monitoring
6. Demonstrate knowledge of different detector systems, the appropriate choice of detector and counting statistics

CONTENTS

Core Learning Outcomes for Nuclear Medicine Technology, Radiation Physics Technology and Radiotherapy Physics Technology

Physics and Instrumentation 15cp

1. Display an understanding of the fundamental concepts of DC and AC electricity and magnetism, structures of matter & its properties.
2. Describe simple kinetic theory of matter and explain how temperature is defined & measured.
3. Describe and explain types of waves and radiation
4. Demonstrate knowledge of components of an instrumentation system. Describe the components of a generalised instrument system and have a knowledge of range of system parameters.
5. Demonstrate an understanding of signal processing techniques to measure physiological signals

Medical Imaging 15cp

1. For each modality (Radiology, Fluoroscopy, CT, Ultrasound, Nuclear Medicine, MRI, Digital Imaging, PET, Mammography) describe and explain the principles of operation
2. Describe and explain the clinical applications of each modality
3. Describe and explain the possible health effects of each modality
4. Describe and explain the legislative framework surrounding the use of each modality
5. Critically evaluate the risks and benefits of each modality

Non-ionising Radiation 15cp

1. Describe and explain the electromagnetic spectrum
2. For each type of radiation (Ultra-violet, RF and microwaves, Lasers, Infra-red, Magnetic fields) describe and explain the sources and physical properties
3. Describe and explain the biological effects and measurement of each type of radiation
4. Describe and explain the possible health effects and safety of each type of radiation
5. Describe and explain clinical applications of each type of radiation

Medical Electronics and Equipment Management 15cp

1. Demonstrate an understanding of the full equipment lifecycle
2. Describe and explain the legislative framework surrounding the use of medical devices
3. Understand basic analogue and digital electronics
4. Demonstrate a basic understanding of microprocessors and circuit design and construction
5. Demonstrate an understanding of the safety of medical electrical equipment

CONTENTS

Specialist modules for the first 2 years of the degree programme (Level)

Medical Engineering Technology: Knowledge and use of equipment 30cp

1. Demonstrate an understanding of a scientific and engineering principles behind a range of medical devices
2. Understand how physiological signals are produced
3. Understand the necessary transducers and/or electrodes required for making measurements
4. Correctly calibrate measurement equipment
5. Understand the electrical safety requirements of medical devices

Radiation Engineering Technology – see Radiation Physics Technology

Rehabilitation Engineering Technology 30cp

1. Define Assistive Technology and Rehabilitation Engineering
2. Understand medical and social models of rehabilitation
3. Understand rehabilitation engineering workshop practice
4. Describe manufacturing techniques used in Rehabilitation Engineering Technology
5. Understand properties of materials used in Rehabilitation Engineering Technology

Renal Technology 30cp

1. Display an understanding of the fundamental concepts of electricity and magnetism, structures of matter & its properties.
2. Describe simple kinetic theory of matter and explain how temperature is defined & measured.
3. Describe and explain types of waves and radiation
4. Display an understanding of the fundamental concepts of chemistry
5. Describe the principles of haemodialysis techniques and their history and development
6. Describe and explain the function of different types of dialyser membrane.
7. Demonstrate an understanding of adequacy.
8. Explain alternative dialysis methods of attaining clearance of solutes.
9. Describe the role of buffers and electrolytes in dialysis fluids.
10. Explain the reasons that influence choice of concentrate composition.
11. Describe access methods and assess possible advantages and disadvantages.
12. Describe possible dialysis complications or adverse reactions

Nuclear Medicine Technology 30cp

1. Describe and explain radiation dosimetry and protection in nuclear medicine
2. Demonstrate a detailed understanding of the gamma camera, its performance and its uses/applications and quality control procedures.
3. Compare and critically contrast the structure, function and use of different types of gamma camera (planar, scanning, SPECT).
4. Understand the principles of radionuclide production
5. Critically discuss the problems associated with the assay of radioactive material and demonstrate an understanding of the principles of such measurements.
6. Demonstrate an understanding of hardcopy display devices

Radiation Physics Technology and Radiation Engineering Technology 30cp

1. Demonstrate an understanding of the principal clinical sources of radiation
2. Describe and explain the principles of Radiation Protection

3. Describe and explain appropriate national and international legislation and policies
4. Demonstrate an understanding of different types of personal and environmental dose monitors and their use in the medical environment
5. Demonstrate an understanding of the factors affecting the design of radiation facilities
6. Describe the effects of radiation on cells and tissues

Radiotherapy Physics Technology 30 cp

1. Demonstrate understanding of the application of medical imaging to tumour localisation and treatment planning
2. Demonstrate understanding of the interaction of radiotherapy treatment beams with matter
3. Describe and explain the physics and function of radiotherapy/brachytherapy equipment
4. Demonstrate understanding, analysis skills and judgement in radiation dose measurement and calculation in radiotherapy and brachytherapy
5. Demonstrate understanding of the characteristics and choice of appropriate radiation fields for treatment

CONTENTS

Clinical Practice Placement for the first 2 years of the degree programme 45/60cp (Dip HE Level

The clinical practice placement in the first 2 years of the degree programme is intended to introduce and develop appropriate knowledge and expertise for technologists working in Medical Physics and Clinical Engineering Departments. For those undertaking the engineering based degree this module attracts 45cp. For the radiation based degree 60cp.

The technical competences covered in this module are described in the NOS career pathway stage 4

Learning Outcomes

1. Demonstrate an ability to access and use a range of information sources including electronic and paper-based within a clinical context and use this information in the preparation of verbal reports and written assignments
2. Recognise issues around: Human Rights and Health and Safety issues / legislation within a clinical environment, patient identification, management and communication skills and quality assurance
3. Demonstrate understanding and limited participation in the following: equipment management procedures, fault finding and reporting, calibration and operation of equipment and patient investigations within the appropriate Medical Physics Department.
4. Produce a professional portfolio which cumulatively records/provides evidence of the skills and knowledge gained in the first and second year of training

CONTENTS

Learning outcomes to be achieved in the last 2 years of the degree programme (BSc Honours)

Specialist modules for the last 2 years of the degree programme (BSc Honours)

Medical Engineering Technology Clinical Instrumentation 30cp

1. Understand and demonstrate the application of quality management systems relating to design and development of medical electrical equipment and systems.
2. Understand the application of the Medical Devices Directive.
3. Understand CE marking medical electrical equipment and systems including routes to compliance.
4. Understand and demonstrate the application of risk management to medical electrical equipment and systems.
5. Understand and demonstrate the application of the general requirements for safety of medical electrical equipment and systems during the design, manufacturing and implementation of medical electrical equipment
6. Understand and demonstrate the application of electromagnetic compatibility requirements and test for medical electrical equipment and systems.
7. Discuss user requirements relating to the functional, physical and environmental aspects of medical electrical equipment and system design.
8. Discuss and critically evaluate medical electrical equipment and systems design proposals.
9. Design, manufacture, document and test medical electrical equipment and systems.

Medical Engineering Technology: Equipment in the Clinical Environment 30cp

1. Understand the electrical installation requirements for the clinical environment
2. Understand the needs of the equipment, users, clients and others within the clinical environment.
3. Understands the electrical environment in high risk clinical areas (e.g. intensive care)

Radiation Engineering Technology 30cp

1. Understands the construction and design of X-ray tubes and generators
2. Understands the construction and design of radiotherapy treatment equipment
3. Understands equipment management in relation to X-ray and Radiotherapy equipment
4. Understands the electrical installation requirements for X-ray and Radiotherapy equipment
5. Understands electrical and mechanical quality assurance test for X-ray and Radiotherapy equipment

Rehabilitation Engineering Technology 30cp

1. Demonstrate a knowledge and understanding of the full range of assistive technology solutions
2. Demonstrate a knowledge and understanding of the main disabling conditions
3. Demonstrate a knowledge and understanding of the clinical practice of rehabilitation
4. Demonstrate an understanding of the use of biomechanical analysis in assessment and assistive technology design
5. Design bespoke assistive technology solutions
6. Critically appraise the benefits and risks of alternative assistive technology solutions

Renal Technology: Renal Anatomy, Physiology and Pathology, Dialysis Techniques and Technology, Water Treatment 30cp

1. Demonstrate a knowledge and understanding of renal anatomy, physiology and pathology
2. Critically discuss different dialysis techniques and their advantages and disadvantages
3. Demonstrate a knowledge of the standards of water quality required for dialysis treatment

4. Demonstrate an understanding of water treatment processes and quality control testing required for renal dialysis.

Renal Technology: Water Treatment and Quality, Biochemistry, Microbiology and Virology, Modalities and Standards, Psychological and Social implications of Renal Replacement Therapy 30cp

1. Demonstrate an understanding of the biochemistry, microbiology, virology and different modalities of renal replacement therapy
2. Be able to critically discuss the psychological and social implications of renal replacement therapy
3. Demonstrate an understanding of the national and international standards that apply to renal replacement therapy
4. Monitor water quality and interpret the results
5. Understand the implications to changes in water quality due to changes in supply

Nuclear Medicine Technology - Anatomy, Physiology, Pathology and Patient Care 30cp

1. Describe and demonstrate an understanding of anatomy an physiology issues relating to the practice of Nuclear Medicine and development of novel radiopharmaceuticals and techniques
2. Critically discuss the problems associated with the care of patients undergoing nuclear medicine investigations or treatments.
3. Demonstrate an understanding of the procedures, radiation protection and legislative issues surrounding the administration of radioactive materials
4. Demonstrate an understanding of the handling of incidents and relating reporting procedures
5. Describe and demonstrate an understanding of issues relating to health and safety and audit in Nuclear Medicine departments

Nuclear Medicine Technology - Practice of Nuclear Medicine 30cp

1. Demonstrate an understanding of Radiopharmacy techniques including generators, isotope properties and blood labelling techniques.
2. Describe and critically analyse the role of Nuclear Medicine in the diagnosis of disease with particular reference to the skeletal, respiratory and renal systems
3. Critically review and evaluate applications of nuclear medicine in terms of diagnosis and therapy for a range of body systems with due reference to patient care needs.
4. Discuss and evaluate radiopharmaceuticals in terms of radionuclide chemistry, biological behaviour and factors affecting product quality

Radiation Physics Technology - Clinical Applications of Radiation Protection 30cp

1. Explain X-ray production and interaction with human tissue
2. Critically review and evaluate X-ray image formation and recording, techniques, health and safety, legislation/codes of practice, clinical sources and audit requirements
3. Describe and evaluate the role of quality management in the service and calibration aspects of diagnostic radiology physics
4. Demonstrate an understanding of the operation and principles of radiotherapy treatment equipment
5. Demonstrate an understanding of the use of radioactive materials in nuclear medicine

Radiation Physics Technology: Practical Applications 30cp

1. Demonstrate an understanding of the organisational arrangements for radiation protection
2. Demonstrate an understanding of dosimetric methods and critically analyse dose reduction options

3. Undertake radiation surveys and evaluate methods/options for improvement and dealing with radiation incidents and emergencies
4. Undertake performance testing of a range of diagnostic X-ray equipment
5. Undertake calibration/type testing of survey meters
6. Critically analyse the differences between fluoroscopic and interventional radiological equipment and demonstrate an understanding of the physical basis for the difference
7. Collect and analyse appropriate dosimetric information from complex examinations to produce a dose/image-quality optimised examination and survey, evaluate and propose safe working practices in high dose/risk examinations for both staff and patients

Radiotherapy Physics Technology - Anatomy, Physiology, Pathology, Radiobiology & Patient Care 30cp

1. Discuss the requirements relating the application of medical imaging to radiotherapy and appraise the choice of imaging technique
2. Discuss the requirements relating to patient care in the mould room and specify and appraise factors/principles/constraints, which affect treatment regimes and treatment planning.
3. Describe and critically evaluate the principles of Radiobiology applied to external beam Radiotherapy
4. Demonstrate an understanding of and critically evaluate, radiotherapy equipment, the beams produced, their characteristics and how they are analysed
5. Critically review tumour pathology of some common tumour sites
6. Describe target volumes as defined in ICRU 50 and 62 documents
7. Define dose prescriptions and reporting as per ICRU recommendations

Radiotherapy Physics - Practice of Radiotherapy Physics 30cp

1. Demonstrate understanding, analysis skills and judgement in treatment planning, radiation dose measurement and calculation, in radiotherapy (external beam/brachytherapy)
2. Demonstrate understanding, comprehension and judgement in the positioning and immobilisation of patients undergoing radiotherapy
3. Demonstrate understanding, comprehension and judgement in the operation of radiotherapy equipment and associated quality control procedures and systems
4. Critically discuss the principles of radiation protection in radiotherapy (external beam/brachytherapy)
5. Demonstrate an understanding of the relevant principals relating to the calculation of dose distributions within patients

CONTENTS

Clinical Practice Placement for the last 2 years of the degree programme 30cp (BSc Honours)

The clinical practice placement in the last 2 years of the degree programme should build upon the knowledge and expertise for technologists working in Medical Physics and Clinical Engineering Departments covered in the first. It should be seen as the second stage in a continuum delivered over 4 years of the programme, enabling the student to gain increasing professional competence.

The technical competences covered in this module are described in the NOS career pathway stage 5

Students will further develop and apply concepts and practices relating to Health and Safety and human rights: e.g. health and safety legislation / protocols (manual handling, basic life support, first aid, electrical safety, COSHH, accident/incident reporting, infection control), data protection, confidentiality, ethics, rights and responsibilities of individuals, equal opportunities.

Learning Outcomes

1. Demonstrate increased knowledge, understanding and confidence in application, of the core skills in clinical, patient identification, communication skills and management, and quality assurance.
2. Demonstrate competence for routine tasks / situations in equipment management procedures, fault finding and reporting, calibration and operation of equipment, and patient investigations within an appropriate Medical Physics or Clinical Engineering Department
3. Critically review and evaluate departmental protocols in relation to the core skills in Health and Safety, human rights, Patient identification, communication skills and management, quality assurance
4. Critically review and evaluate routine tasks in relation to, fault finding and reporting, calibration and operation of equipment within the appropriate Medical Physics Department.
5. Produce a Professional portfolio which cumulatively records / provides evidence of the skills, knowledge and attitudes gained in the third and fourth year of training.

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Clinically based project. 30cp

Students are required to undertake a clinically based project during the final year of the course. Within the project, the student integrates and applies material presented throughout the other modules and applies them to a clinically relevant research question. In this module, the student is given an opportunity to investigate the subject area of the project and is directed to sources of information for project preparation, management and delivery.

Learning outcomes

1. Formulating a properly focused and research question
2. Appropriate selection of methods and procedures to investigate the research question
3. Acquisition of more advanced skills in research techniques
4. Understanding of ethical issues related to research with human participants if appropriate
5. Gaining greater familiarity with performing statistical or other analytic techniques
6. Gaining greater familiarity with organising or manipulating research data
7. Writing a research report with appropriate content and format

CONTENTS

Indicative the first 2 years of the degree programme (Dip HE level).

Core topics

Anatomy and Physiology

For each organ/system the student must be able to describe the

- Gross anatomy
- Surface anatomy
- Function
- Physiology
- Common pathology
- Medical terminology

Cells and Tissues

- Cell composition, division
- Embryology
- Types and sites of tissues
- Matrix substances, blood, skin

Skeleton

- Bones, muscles and joints
- Bone structure, osteogenesis.
- Bone joint abnormalities, fractures, tumours, infections.

The Nervous System.

- Physiological anatomy of the brain
- Main subdivisions and lobes
- Grey and white matter.
- Arterial and venous circulation.
- Blood brain barrier.
- Cerebrospinal fluid and its circulation.
- Vascular incidents.
- Space occupying lesions.

Endocrine System.

- Hormone production and feedback mechanisms.
- Endocrine glands
- Menstrual cycle.
- Pathological conditions, under and over production of hormones.
- Space occupying lesions.

Cardiovascular System.

- Blood Vessels - arteries, capillaries and veins.
- Central and peripheral circulation.
- The heart as a pump. Myocardium and cardiac chambers. The coronary circulation.
- Pulmonary and systemic circulation.
- Cardiac output.
- Ejection fraction, wall movement.
- Conduction system
- Coronary disease.
- Impaired cardiac function.
- Homeostasis

- Pathology of blood vessels; arterial and venous thrombosis; aneurysm.

Respiratory System

- Respiratory pathways; trachea, bronchi and lungs
- Gaseous Exchange
- Interrelation between alveoli and lung capillaries
- Obstructive pathology, SOL

The Kidneys and Urinary Tract.

- Structure of kidneys, ureters and bladder.
- Formation of urine, renal perfusion
- Glomerular filtration, tubular function; absorption and secretion
- Homeostasis
- Obstructive uropathy, reflux, renal failure space occupying lesions; infection
- Consequences of renal failure
- Renal transplantation

Gastrointestinal System.

- The alimentary tract; passage of fluid and solid through the tract, digestion,
- Malabsorption, SOL, IBD
- Liver and its functions, hepatocytes, bile formation, gall bladder and bile ducts.
- Pathological conditions; space occupying lesions, jaundice, acute cholecystitis, bile reflux
- Pancreas

Hemopoietic and Lymphatic Systems

- Composition and function of blood; plasma and cells
- Coagulation.
- Bone marrow and spleen.
- Reticuloendothelial system.
- The lymphatic system; circulation of lymph.

Reproductive System

- Genitalia
- Pregnancy and foetal development
- 10/28 day rule
- SOL

Sense Organs

- Ear, Nose
- Tongue
- Skin
- Eyes

CONTENTS

Mathematics and Statistics 15cp

Mathematics

- Numerical representation and scientific calculator use: standard form, negative numbers, percentages, accuracy & precision, conversion of units of measure
- Algebra: review of basic concepts
- Graphs: linear and non-linear graphs in the x-y plane, plotting a graph of the function, solving equations using graphs, solving simultaneous equations graphically
- Logarithmic expressions: indices, laws of indices, laws of logs, combinations of logs, natural logs & base 10 logs, solving equations with logarithms, properties and graph of ln and log function
- Angles and Trigonometry: degrees, radians, trigonometry ratios (sin, cos, tan), solving trigonometric equations, maxima & minima, graphs and waves generated by trigonometry
- Exponential Functions: exponential expressions, exponential function and its' graph, solving equations involving exponential terms using a graphical method.
- Reduction of non-linear laws to a linear form
- Complex numbers
- Determinants, matrices and vectors
- Differentiation: gradient function, rules for differentiation, higher derivatives, maximums, minimums, points of inflection, differentiation of sums, differentiation of differences
- Advanced differentiation: products, quotients, exponential functions, logarithmic functions, function of a function, partial differentiation, differential equations
- Indefinite Integration: indefinite integration, some rules for indefinite integration, constant of integration
- Definite integration: areas under curves, areas bounded by lines and curves, finding areas where some or all lie below the x-axis.
- Fourier series, vector analysis, complex variables, Laplace transforms

Statistics

- Types of Data: Discrete and continuous data
- Summarising data graphically: dotplot, stem and leaf, box and whisker, grouped frequency distribution, histogram, cumulative frequency distribution, cumulative frequency polygon, bar chart, one and two variable data. Correlation and regression.
- Summarising data numerically: mean, median, mode, samples, when to use various averages, standard deviation, error, inter quartile range, box and whisker plots, variance, range, measures of skewness
- Normal distribution: mean, s.d., areas under the curve, standard normal transformation, solution of problems
- Simple probability. Samples and Population Distributions: reasons for sampling sample size, random sampling, biased sampling, quota sampling, systematic sampling and stratified sampling, relationship to normal distribution, primary and secondary data.
- Chi-Squared: Basic chi-squared test, significant testing, contingency tables (any size), Yates' correction, degrees of freedom, hypothesis tests
- Confidence Intervals: 95 % , 99% confidence intervals for the mean, large samples, t – distribution for confidence intervals with small samples, degrees of freedom
- ANOVA: data collection, factors and factor levels, one way (factor) ANOVA, notational and computational formula, ANOVA table, Two way (factor) ANOVA ,assumptions and hypothesis tests
- Formulating Hypothesis: null and alternative hypothesis, one and two sided tests, significance level, type 1 and type 2 errors, testing the mean of a population
- Parametric Tests: Testing the mean of a population of differences for paired and unpaired data
- Non-Parametric Tests: Sign Test, Wilcoxen and Mann-Whitney tests to be looked at. Reasons for using the various parametric and non-parametric tests.

CONTENTS

Health & Safety, Research Methods & Hospital Practice

Health & Safety

- The Health and Safety at Work Act and its provisions
- The duty of employers and employees in ensuring safety in the workplace
- The duty to patients, other members of staff and the general public
- Microbiological safety, cleaning and disinfecting, control of infection
- Local accident and incident reporting
- System for notification of untoward incidents, faults and hazards
- Hazard Warning and Safety notices
- Fire extinguishers, fire precautions and emergency procedures
- Electrical, mechanical, chemical and biological safety
- Consumer Protection Act
- Radiation legislation.
- Risk analysis and assessment

Management/Hospital Practice/Quality

- Overview
    - National Health Service
    - Hospitals/NHS Trusts
    - Medical Physics and Clinical Engineering Departments
- Hospital Practice
    - National and local procedures
    - Clinical governance
    - Clinical audit
- Quality Systems
    - Meaning of quality, quality assurance and quality control
    - Quality standards
    - Assessment of quality
    - Quality management systems, records and audit

Patient Care

- Welcome, explanation, comfort, instruction, farewell.
- Dealing with: carers, relatives, children, elderly, mentally disturbed, blind, deaf, uncooperative, etc.
- Care of chair and stretcher patients
- Moving and handling
- Handling the unconscious, anaesthetised or disabled patient.
- Discuss appropriately with patients or clients procedures being undertaken
- Demonstrate an ability to communicate and explain complex or sensitive Issues to patients, relatives and staff

Research Methods

- Ethics.
- Staff/patient relations and disclosure of information.
- Personal and professional responsibility for research project planning and management,
- Literature review, critical appraisal
- Clinical audit

Emergency Procedures.

- First aid
- CPR - Cardiopulmonary Resuscitation

CONTENTS

Computers and IT

Computer Hardware and programming

- Hardware
- Microprocessor technology
- Basic microprocessor hardware
- Data transfer
- Interfaces
- Computer arithmetic
- Boolean algebra
- Coding and representation of information
- Storage of information
- Computer languages

Data security, use of applications

- Data security, data management and legal aspects, e.g. Data Protection Act
- Database: Create a database and understand the basic principles of database, interrogate and produce reports, evaluate and amend the database
- Spreadsheet: Creating worksheets, names, ranges, addresses, copying, formatting, deleting, moving, text, data, series; using and creating a wide variety of charts, graphs and graphics (e.g. log linear graphs, 3D bar charts)
- PowerPoint: Create a short PowerPoint presentation and understand the basic principles of PowerPoint. Apply appropriate techniques and slides for presentation. evaluate and amend the presentation
- Data Handling
- Electronic mail, data transmission
- Use of Internet

CONTENTS

Core Topics Medical Engineering Technology, Rehabilitation Engineering, Radiation Engineering and Renal Technology

Electronic Principles 30cp

Electronic Principles

- Semiconductor theory
- Diodes
- Transistors
- Amplifier using transistors
- Transistor circuits and equivalents
- Logic circuits
- Differential amplifiers
- Feedback amplifiers
- Operational amplifiers
- Power amplifiers
- Systems and stability
- Noise
- Signal processing
- Modulation
- Integrated circuits

Circuit Theory

- Circuit elements
- Resistive circuits
- Capacitive and inductive circuits
- D.C. steady state
- Forced responses
- Sinusoidal excitation
- Resonant frequencies
- Power and Energy
- Complex number approach
- Non-periodic inputs

CONTENTS

Digital systems

- Digital versus analogue electronics
- Digital logic, Logic Circuits, functions and gates, Memory types
- Basic memory devices
- Microprocessor architecture
- Instruction sets, registers and counters
- Memory and peripheral devices
- Programming
- Comparison of low and high level languages
- Application to simple control problems
- Signal sampling, Analogue and digital signals
- Digital to analogue conversion, Analogue to digital conversion
- Transducers and the interfacing of analogue and digital circuits
- An overview of interface standards such as RS232C, USB, I2C
- System testing techniques

CONTENTS

Mechanics and Materials

Mechanics

- Fundamental concepts; Units of measurements; International system of units; numerical calculations.
- Forces and moments: equilibrium of a particle; free body diagram; force system resultants; principle of moments; moment of a force; moment of a couple; Resultant forces and couples; equilibrium of planar system of forces; graphical and analytical method.
- Internal forces: Shear and moments; relation between distributed load, shear and moment; stress and strain; tensile and compressive stress and strain; factor of safety
- Hooke's Law and elastic constants
- Friction: dry friction; frictional forces on screws, belts and bearing, rolling resistance.
- Moment of area: first and second moments; polar second moment of area; centroids; theorem of perpendicular axis.
- Bending of beams: stresses due to bending, neutral axis, radius of curvature, moment of resistance, general bending formula.
- Torsion of shafts: stresses due to top twisting, angle of twist, general torsion formula, power and work.

Fluid Mechanics

- Basic properties, viscosity
- Hydrostatics: Definition of pressure and shear stress
- Piezometer tube, Barometer, use of manometers.
- Introduction to Fluid flow: General principles and common simplifications in fluid flow.
- Laminar flow
- Bernoulli's equation, flow measurements.
- Turbulent flow in pipes
- Friction loss in pipe systems, pumping power

Materials

- Introduction to the selection and classification of materials
- The basic properties of materials including chemical, electrical, mechanical, physical and durability properties
- The relative importance of various material properties in different applications
- The microstructure of materials and its effect on chemical, electrical, mechanical and physical properties
- Introduction to material selection and the concept of choosing an appropriate material for a design application
- Biocompatability of materials

CONTENTS

Core Topics for Medical Engineering Technology, Rehabilitation Engineering and Renal Technology

Engineering Design

The Design Process

- Customer requirements, manufacturing constraints, quantity, standards, analysis of requirements
- Writing a Product Design Specification.
- Idea creation.
- Evaluation of design solutions and design solution identification.
- Development of a design solution.

Engineering drawing

- The use of views, sections, dimensions and tolerances.
- Arrangement, detail and assembly drawings, parts lists

The use of a 2D CAD program to include the following:

- Draw, copy, move, rotate, scale and mirror features and collections of features;
- Delete, extend and trim features.
- Use layers and appropriate line types.
- Use cells or blocks to establish a library of commonly used symbols or components.

The use of 3D Solid Modelling CAD

CONTENTS

Measurement & Sensors

Sources and Nature of Physiological Signals

- Electrical in origin (ECG, EMG, EEG, evoked responses, etc)
- Non-electrical in origin (blood pressure, temperature, SaO2, etc)

Measured Parameters

- For each parameter understand the origin and magnitude of signal, normal frequency range and the likely origin of artefacts.
    - ECG, EMG, evoked potentials, etc.
    - Temperature
    - Oxygen saturation
    - Flow rate
    - Pressure
    - pH
    - Volume/displacement (including plethysmography)
    - Force
    - Gas concentrations (helium, carbon monoxide, etc.) partial pressures/saturation of oxygen)
- Principles of electro-impedance tomography

Transducers – Electrodes

- Electrodes (contact and polarisation potentials)
- Temperature (thermistor, thermocouple etc.)
- Pressure (including pneumotachograph)
- Flow rate (electromagnetic, optical etc.)
- pH
- Gas sensitive

General Purpose Physiological Measurement Systems

- For each system understand how it is set up and checked for correct operation.
- Electrodes and transducers (contact and polarisation potentials, equivalent circuits)
- Amplifiers and processing units
- Filters
- Signal averaging
- Signal display and recording
- Evaluation
- Calibration

Specification of Equipment for Measuring Electrical Signals

- Electrode type and positioning
- Skin and equipment preparation
- Nature and source of signal
- Artefact recognition
- Data storage and review
- Calibration techniques
- Diagnostic usefulness and significance

Specification of Equipment for Measuring Non-Electrical Signals

- Transducer type and interfacing with patient
- Setting up procedures
- Nature and source of signal
- Artefact recognition
- Data storage and review

- Calibration techniques
- Diagnostic usefulness and significance

Physiological Data Processing

- Visual (eyeballing) interpretation
- Computer assisted
- Computer automated
- Export to other programmes
- Data analysis/reporting

Ambulatory Monitoring

- Magnetic tape
- Digital

Errors

- Sources of error
- Propagation of errors
- Tolerances
- Calibration

CONTENTS

Biomechanics

- Classification and nomenclature of directions, planes, axes and human movement
- Identification of key bones, classification of joint types, their structure and motion
- Identification of muscle types and key muscle groups.
- Muscle function, power, fatigue
- Classification of joint types, their structure and motion
- Mass, gravity, weight, force, moment, velocity, acceleration
- Linear and angular movement, momentum, inertia
- Temperature, energy, work, efficiency, physiological cost index
- EMG
- Qualitative kinematics - systematic description of human movement and identification of pathology
- Quantitative kinematics - techniques for quantifying movement and applications of kinematics
- Introduction to gait analysis – the gait cycle, key measurements, clinical applications

CONTENTS

Core Topics for Nuclear Medicine Technology, Radiation Engineering Technology, Radiation Physics Technology and Radiotherapy Physics Technology

Ionising Radiation Physics

Atomic Structure

Atomic and nuclear structure, mass number, atomic number
Isotopes
Alpha, beta and gamma radiation
The electron volt
X-rays

The Laws of Radioactive Decay

Half life, mean life, physical half life
The units of activity
Specific activity, radioactive concentration
Parent - daughter relationships

The Mechanism of Radioactive Decay

Alpha, beta and gamma emission, neutrons
Electron capture, positron emission
Characteristic radiation
Isomeric transition
Internal conversion
Equilibrium
Decay schemes and energy level diagrams

Production of X-rays

General principles
Electromagnetic spectrum
Production of X-rays (low to megavoltage)
Filters

Interactions of Radiation with Matter

Radiation quality - HVL and TVL
Attenuation, absorption and scatter (photo-electric, Compton scatter and pair-production) Attenuation coefficient
Exponential attenuation of monoenergetic photons,
Electrons scatter and bremsstrahlung
Ionization and excitation
Pair Production
Electron range and energy
Inverse square law
Filters and filtration
Effects of electron/photon energy, absorber density and atomic number
Tissue equivalent materials

Biological Effects of Radiation

Cellular Level/DNA
Classification of Effects – Deterministic and Stochastic
Specific Risks in Pregnancy
Dose Models
Epidemiological Data – Bomb Survivors/Radium Dial Painters/Early Radiologists
5% per Sv
Medical radiation risks and equivalent risks

Radiation Units and Dosimetry

Absorbed dose (Gray/Kerma)
Dose equivalent (sievert)
Weighting factors

Natural and Manmade Radiation

Cosmic and solar radiation
Radiation from terrestrial sources
Sources present, pathways and quantities
Medical exposure in context
Radioactive waste
Power stations and other nuclear sites
Fall out, weapon testing
Man made radioactive isotopes Iridium, Iodine Caesium etc

Radiation Protection

Shielding, distance and time
Dose limits, personal and environmental
Introduction to IRR99, IRMER and MARS
Controlled and supervised areas, classified persons
Roles and responsibilities of staff, including RPA, RPS
Hospital organisation of radiological protection; local rules
Personnel and environmental dose monitoring
Registration, safe custody, leak testing, use and disposal of radioactive sources
Record keeping

Radiation Detectors

For each detector system:

Principles
Construction
Uses
Limitations
Associated equipment

Detector Systems:

Ionisation chamber.
Geiger tube
Sodium iodide and other scintillators
Liquid scintillation detection
Solid state detectors
Photographic film
Thermoluminescence detectors (TLD)
Optically Stimulated Luminance (OSL)
Chemical detectors –e.g. gafchromic film
AmSi detectors

CONTENTS

Core Topics for Nuclear Medicine Technology, Radiation Physics Technology and Radiotherapy Physics Technology

Physics and Instrumentation

- DC electricity
    - Ohm's law, potential dividers, bridge circuits, Seebeck effect, temperature coefficient.
- AC electricity
    - Ohm's law for AC, reactance, impedance, phasor diagrams
- Magnetism
    - Permanent
    - Electromagnetism – motor effect and principles of electromagnetic induction
- Properties of matter
- Definitions of force, energy and power.
- Waves
    - Longitudinal - production and propagation
    - Transverse - electromagnetic production and propagation including laser.
    - The electromagnetic spectrum
- Ionising and non-ionising radiation
    - Simple properties of α, β, γ, X-ray
    - Lasers
    - Ultrasound
    - NMR
- Temperature
    - Zeroth law and its measurement, temperature scales
- Gases and liquids
    - Simple kinetic theory, evaporation and boiling
- Atomic structure
    - Simple Bohr atom model.
    - Bonding – ionic and covalent
- Instrumentation
    - Components of an instrumentation system, matching, source and internal impedance, fault finding.
    - System parameters (gain, linearity, accuracy, precision, error, resolution, hysteresis, sensitivity, bandwidth, frequency response and damping, time constant, noise, signal to noise)..
    - Power supplies and isolation
    - Recording media
    - Displays
    - Measurement of physiological signals

Medical Imaging

Principles of operation

- Formation of the X-ray image
- Film/screen combinations
- Fluoroscopy
- CR/DR
- Mammography
    - Basic Physics
    - Formation of the image
    - NHS Breast Screening Programme
- CT scanners
    - Generations of CT Scanner
    - Basic Physics

    - Formation of the image
- Ultrasound
    - Basic physics
    - Transducers
    - Formation of the ultrasound image
- Nuclear Medicine
    - Construction of the gamma camera
    - Factors affecting the formation of the image
- MRI
    - Basic physic
    - Formation of the image
- Digital imaging
    - Basic image manipulation
    - PACS
- PET
    - Basic Physics

Application

- Describe common clinical applications of each modality
- Describe the possible risks and health effects
- Legislative framework and guidance
    - IRMER
    - MARS
    - ARSAC
    - Physical Agents Directive
- Choice of modality for different common clinical problems

CONTENTS

Non-ionising Radiation

Physical properties and sources

- The electromagnetic spectrum
- Ultraviolet
- RF and microwaves
- Lasers
- Infra-red
- Magnetic fields
- Measurement of each type of radiation

Application

- Biological effects of each type of radiation
- Clinical application of each type of radiation
- Safety issues associated with the use of each type of radiation

Legislation and guidance

- ICNIRP
- Physical Agents Directive

CONTENTS

Medical Electronics and Equipment Management

- Legislation and responsibilities
- Standards and Codes of Practice
- Safety issues and risk management
- Equipment planning procurement and replacement
- Equipment acceptance, maintenance, control and user training
- An introduction to analogue electronics
- An introduction to digital electronics
- A to D and D to A conversion
- Basic microprocessor techniques
- Basic principles of circuit design and construction
- Safety of medical electrical equipment

CONTENTS

Specialist modules for the first 2 years of the degree programme (Dip HE Level)

Medical Engineering Technology: Knowledge and use of equipment

To apply theoretical knowledge and models in order to gain a thorough understanding of the operation of medical devices.

- Suction
- Nebulisers
- Spirometers
- Infusion Devices
- Temperature and Blood Pressure Monitoring
- ECG Recorders
- Oxygen Analysers
- Carbon Dioxide Monitors
- Electrosurgery Equipment
- Blood Gas Analysers
- Ventilators
- Endoscopic Systems
- Dialysis Equipment
- Physiotherapy, Audiology and Ophthalmology Equipment
- Lasers.

CONTENTS

Radiation Engineering Technology

In the first two years of the degree Radiation Engineering Technologists will take the same specialist modules as the Radiation Physics Technologist

CONTENTS

Rehabilitation Engineering Technologist

- International Classification of Functioning, Disability and Health – ICF
- The multi-professional team
- Introduction to assistive technologies
- Workshop safety
- Production planning and processes
- Hand tools. machine tools and computer aided manufacture
- Fixing and fastening
- Metals, plastics, wood, ceramics, biomaterials

CONTENTS

Renal Technologist

Physics - Basic principles of physics

- Basic principles
- Atomic structure
- Gases and liquids
- Energy
- Magnetism
- Mechanics
- Waves (longitudinal and transverse)
- Thermodynamics – zeroth law and its measurement
- Ionising and non-ionising radiation properties
- Measurement parameters - static and dynamic characteristics, gain, sensitivity, linearity, calibration, frequency response, effects on recordings
- Recording media and storage
- Interfaces e.g. equipment to computer

Chemistry - Basic chemistry Principles

- Chemical quantities, mass, formulae and equations
- Structure and bonding
- States of matter, energies and reactions
- Periodic table
- Mixtures, compounds and solutions
- Acids and alkalis
- Ionic compounds
- Metals
- Fuels
- Equilibrium
- Organic and inorganic chemistry
- Instrumental analysis

Principles of Dialysis - physiological and mechanical

- Acute and chronic dialysis
- Body water composition
- Vascular access
- Thermal balance
- Blood volume
- Body chemistry
- Sodium balance
- Potassium and calcium homeostasis
- Assessment of dry weight
- Blood pressure monitoring and control
- Urea clearance and Na dialysance
- Glucose homeostasis
- Dialysis adequacy
- Buffers, electrolytes and concentrates
- Transport mechanisms
- Artificial kidney and dialyser membranes
- History and development
- The dialyser
- Clearance
- Dialysis complications

CONTENTS

Radiation Hazards

- The biological effects of radiation as in ICRP 60 and deterministic effects, stochastic and non-stochastic effects, detriment weighting factors
- Annual limit of uptake and derived units
- Legislative framework

Dosimetry of Unsealed Radionuclide Sources

- Absorbed dose, dose equivalent and units
- Concept of effective dose equivalent
- Principles of calculation of radiation dose from administered radiopharmaceuticals
- MIRD tables, selection and properties of radionuclides for particular diagnostic or therapeutic applications

Principles of Radionuclide Production

- Carrier free radionuclides
- Radionuclide generator systems: growth and decay curves, elution profiles
- Available generator systems and their construction
- Cyclotron and reactor production, general principles

Nuclear Properties of Radionuclides Used in Nuclear Medicine

- Atomic weight, number, half life, mode of decay, principal emissions

Mathematical Methods

- Counting statistics, precision of net sample counts
- Isotope dilution methods
- Flow studies, Fick principle, initial slope, transit time
- Convolution and deconvolution methods
- Clearance techniques, exponential analysis

Image Hardcopy Display Systems

- Aperture, focus, magnification, depth of field and distortion
- The photographic process. Processing methods
- The response of film, characteristic curve, optical density, contrast, fog level
- The importance of adequate grey scale information
- Film hardcopy systems used in Nuclear Medicine
- X-Y dot imager, video, imagers, colour printers, laser printers
- Cleaning, adjustment and maintenance

The Assay of Radioactivity

- The problems associated with assay
- Background and shielding
- Counting loss associated with dead time and its correction
- Efficiency and the optimisation of counting conditions, dual isotope counting
- The geometry of the detecting system
- The assay of radioactive samples
- Gamma emitters:
    - Scintillation detector systems: well crystals, flat crystals, large sample plastic scintillation detector systems, dual isotope counting
- Beta emitters
    - Geiger devices, liquid scintillation counters, sample preparation, quench correction, practical problems of assaying samples
- Radionuclide identification
    - The scintillation detector system: limitations of energy resolution

    - Solid state detector systems
    - The multichannel analyser
- The use of ionisation chambers
    - The re-entrant ionisation chamber at atmospheric pressure, the high pressure chamber
    - Precautions necessary for accurate activity measurements
- The measurement of gamma radiation using probe scintillation detectors
    - Properties of collimators for low, medium and high energy emissions
- Quantification of uptake, relative and absolute
- Use of standards, background and phantoms
- Whole body monitors
    - Types: shielded rooms, shadow shield, chair, scanning, stationary multi-detector
    - Properties of whole body counters, uniformity of response, sensitivity and background in relation to precision

The Imaging of a Radionuclide Distribution

- The Gamma Camera
    - The components of a gamma camera
    - The head unit, crystal, light guide, photomultiplier assembly, head electronics
    - The purpose and construction of collimators: parallel, diverging, pinhole, converging, biplane, high, medium and low energy, high sensitivity, high resolution
    - The effects of the collimator on the acquired image
    - The control console, parameters which can be selected
    - Interface to the computer
- Special types of gamma camera
    - The scanning gamma camera
    - The emission tomography gamma camera
    - The performance of a gamma camera – quality control
    - Setting of pulse height analyser(s)
    - Uniformity of field sensitivity
    - Spatial resolution and linearity
    - Display performance and adjustment
    - Measurement of sensitivity and count rate capability
    - Phantoms and sources for quality control measurements
- Emission tomography, general principles, practice and quality control
    - Image quality
    - The specification of the resolution of an imaging system by means of the line spread function
    - The effect on image quality of administered activity, investigation time and counting statistics
    - Factors affecting overall system performance

CONTENTS

Radiation Physics Technology and Radiation Engineering Technology

Clinical Sources of Radiation

- Production of X-rays
- Types of X-ray tube and design features
- X-ray generators
- Sealed sources
- Unsealed radioactive materials

Diagnostic X-ray Installations

- Radiography
- Fluoroscopy: over-couch and under-couch system, fluorography
- Computer tomography (CT)
- Digital systems (radiography, subtraction and enhancement techniques)
- Mobile units dental units, dental panoramic tomography, cephalometry
- mammography
- Room layouts, control cubicles, shielding
- Primary beam, scatter, leakage
- Films, screens and film processing/Computed Radiography
- Factors affecting patient dose

Radiotherapy Treatment Machines

- Room design, shielding
- Linear accelerators, cobalt units, deep X-ray units
- Superficial units, simulators
- Photon beam generation
- Electron beam generation
- Cobalt teletherapy
- Cyclotron

Radiation Protection

- ALARA
- Principles of dose limitation
- Net positive benefit, dose limits
- National and International legislation and recommendations
- Controlled and supervised areas, classified persons
- Roles and responsibilities of staff, including RPA, RPS
- Hospital organisation of radiological protection; radiation safety policy, local rules
- Personnel and environmental dose monitoring
- Instrument calibrations
- Registration, safe custody, transport, use and disposal of radioactive sources
- Contingency plans, including radiation emergencies
- Notification of radiation accidents and incidents
- Biological and effective half life
- Record keeping

Dose Monitoring

- Film, TLD and OSL monitoring
- Pocket dosimeters
- Operation of a personal monitoring service and approved dosimetry service
- Whole body, extremities, eyes, thyroid

Design of Facilities

- Equipment circuit breakers, interlocks; warning signs

- Use of distance, shielding, time
- Calculation of shielding requirements
- Environmental radiation surveys

Radiobiology

- Effects of radiation on cells and tissues
- Cell survival concepts of tissue tolerance, fractionation, oxygenation, cell proliferation
- Radiation hazards: early and late reactions; genetic and carcinogenic risks

CONTENTS

Medical Imaging Applied to Radiotherapy

- Radiography
  - Intensifying screens
  - Anti-scatter grids
- Fluoroscopy
  - Image intensifier
  - Fluoroscopic image display
- Digital Radiography
- Treatment Simulators
  - Tube design
  - Collimation and delineation
  - Image intensifier
  - Isocentric mounting
  - Movements
- Computed Tomography
  - Principles of operation
  - Slice width and pitch
  - CT numbers
- Magnetic Resonance Imaging
  - Principles of operation
  - Imaging sequences
  - Tissue properties
- PET imaging
- Ultrasound

Interactions of Radiation with Matter with Respect to Radiotherapy

- Photon interactions and their relevance in radiotherapy imaging and treatment
  - Photoelectric
  - Compton
  - Pair production
  - Photo disintegration
- Beam energy
  - Total attenuation
  - Beam energy specification
  - Effect of attenuating materials
- Electron interactions and their relevance in radiotherapy
  - Inelastic collisions
  - Bremsstrahlung
  - Radiation losses
  - Characteristic x-rays
  - Elastic collisions
  - Electron scattering
  - Energy specification, range, energy at depth
- Neutron interactions and their relevance in radiotherapy

External Beam Radiation Treatment Equipment

- Construction and principles of operation of:
  - Very low energy, low energy, medium energy x-ray equipment
  - Tube design
  - Target
  - Cooling
  - Filtration
  - Applicators
  - Dose monitoring

- Linear Accelerator
    - Gun
    - Waveguide
    - Beam steering
    - Target
    - Flattening filter
    - Collimation, including MLCs
    - Dose monitoring
    - Isocentric mounting
    - Movements
    - Creation of wedged fields
    - Switching from electrons to photons
- Photon beam generation
- Electron beam generation
    - Cobalt teletherapy
    - Cyclotron

Dose Distribution

- Central axis depth dose
    - Percentage depth dose
    - Tissue air ratio
    - Tissue phantom/tissue maximum ratio
    - Factors affecting depth dose - inverse square law
- Irregular fields - equivalent square – sector integration
- Off-axis dose - dose in shielded regions - scatter/primary beam hardening
- Isodose curves
    - General properties
    - Parameters affecting isodose curves
- Beam quality, source size, source surface distance, source collimator distance, beam flatness, flattening filters, field size, penumbra, oblique incidence, tissue heterogeneity
- Summation of isodose curves
- Beam weighting
- Guidelines for field arrangements
- Large field treatment techniques
- Field matching asymmetric collimators
- Effect of change in radiation beam energy

Dose Measurement

- Kerma and absorbed dose
- Dosimeter construction, mode of operation
- Clinical dosimetry equipment
    - Ion chamber
    - Film
    - TLD
    - Diodes
- Phantoms

Electron Beams

- Depth dose characteristics
    - Energy-range
    - Skin dose
    - Build-up
    - Field size effects
    - Photon contamination
    - SSD
    - Virtual source

- Isodose curve characteristics
    - Penumbra
    - Collimation
    - Shielding
- Oblique incidence
    - Tissue heterogeneity

Brachytherapy Materials and Equipment

- Sources - nuclide, structure, identification
- Afterloading equipment

CONTENTS

Specialist topics for the last 2 years of the degree programme (BSc Honours)

Medical Engineering Technology Clinical Instrumentation 30cp

Biological signals and applied signals

- For each Physiological Signals, understand the origin, nature, transmission and characteristics of the signal including the magnitude and normal frequency range.
    - Electrical in origin (ECG, EMG, EEG, evoked responses, etc)
    - Non-electrical in origin (blood pressure, temperature, SaO2, etc)
- Identify the likely origin of artefacts, which may affect the physiological signal and the principles that may be used to reduce them.
- Understand the affect, outcome of applying a signal/ source of stimulation to the human body considering the magnitude, frequency, transmission and limitations and restrictions
- Understands the basic principles and technology of transducers used in the detection, measurement, recording or analysis of physiological signals or parameters
- Describe the selection of appropriate transducers for the detection or application of biological signals understanding any technological issues relating to
    - Nature and source of signal
    - Transducer type, size and positioning
    - Skin and equipment preparation
    - Artefact production or pickup
    - Setting up procedures
    - Usability and patient acceptability
    - Repeatability
    - Safety

Standards and Legislation

The student must be familiar with the following:

- Medical electrical equipment - General requirements for safety (EN60601-1)
- Medical electrical equipment - General requirements for safety. Collateral standard. Safety requirements for medical electrical systems. (EN60601-1-1)
- Medical electrical equipment - General requirements for safety. Collateral standard. Electromagnetic compatibility. Requirements and tests. (EN60601-1-2)
- Medical electrical equipment - General requirements for safety. Collateral standard. General requirements for programmable electrical medical systems. (EN60601-1-4)
- Medical Devices - Quality Management Systems - Requirements for regulatory purposes. (EN13485)
- Medical Devices Directive. (93/42/EEC)
- Medical devices - Application of risk management to medical devices. (EN14971)
- Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements. (EN61010-1)

  The student must also be aware of the 'Part 2' standards associated with EN60601 where particular requirements for safety are identified for specific types of medical electrical equipment.

Quality Management Systems Relating to Design and Development of Medical Electrical Equipment and Systems

- General requirements of a quality management system (QMS).
- Control of documentation.
- Control of records.
- Responsibility, authority and communication
- Resources
- Competence, awareness and training

- Customer focus
- Planning design and development
- Processes, inputs and outputs
- Reviews
- Verification and validation
- Identification and traceability
- Measurement, analysis and improvement
- Internal audit

The Medical Devices Directive, CE Marking and Routes to Compliance

- Essential requirements
- Declaration of conformity
- Type-examination
- Verification
- Devices for special purposes
- Classification criteria
- Clinical evaluation
- Notified bodies

Safety Requirements for Medical Electrical Equipment and Systems

- Environmental conditions
- Protection against electric shock hazards
- Protection against mechanical hazards
- Protection against unwanted or excessive radiation
- Protection against hazards of ignition of flammable anaesthetic mixtures
- Protection against excessive temperatures and other safety hazards
- Accuracy of operating data and protection against hazardous output
- Abnormal operation and fault conditions
- Constructional requirements
- Single fault conditions

Safety Requirements for Programmable Medical Electrical Systems

- Risk concepts
- Development life-cycle
- Requirements specification
- Architecture
- Design and implementation
- Verification and validation
- Modification

Electromagnetic Compatibility

- EMC theory
- Radiated RF emissions
- Conducted RF emissions
- Electro-static discharge immunity
- Radiated field immunity
- Fast transient burst immunity
- Surge transient immunity
- Mains voltage dips and interruptions
- Conducted RF immunity
- Power-frequency magnetic fields
- Other immunity tests
- Pre-compliance testing
- Full compliance testing

- Designing for compliance
- Defined test limits

Requirement Specifications (User, Technical and Legislative)

- Establishing a user specification
- Establishing a technical and environmental specification
- Determining applicable standards and legislation

Design Evaluation

- Analysing designs
- Failure modes and effects analysis

Design, Manufacture, Testing and Documentation

- Design techniques (computer aided design tools)
- Prototyping, simulating, experimentation, modelling
- Using advanced test equipment
- Engineering drawings (electrical and mechanical)
- Printed circuit manufacture
- Constructional issues (wiring, physical layout)
- Functional testing and calibration
- Electromagnetic compatibility testing
- Design verification and validation testing
- Safety testing

CONTENTS

Medical Engineering Technology: Equipment in the Clinical Environment 30cp

Electrical safety, installation and building constraints

- Building constraints
- Electrical installation requirements
- Legislation
- Installation, maintenance and disposal
- Interaction with other electrical devices in the patient environment

User requirements

- Determining individual user needs for medical devices
- Prescribing solutions to meet individual needs
- Specifying medical devices to meet prescription

Equipment lifecycle

- Performance parameters, calibration and tolerances
- Specification and procurement processes
- PPQ, loan equipment, indemnity
- Equipment libraries
- Training
- Local protocols
- Disposal

Infection control

- Infection control
- Decontamination
- Sterilisation techniques and associated legislation
- Endoscope washers and associated legislation

Risk assessment

- Risk assessment of equipment in the clinical environment
- Incident reporting and root cause analysis

CONTENTS

Radiation Engineering Technologist 30cp

X-ray and related equipment

- Production of X-rays
- Types of X-ray tube and design features
- X-ray generators
- Radiography
- Fluoroscopy: over-couch and under-couch system, fluorography
- Computer tomography (CT)
- Digital systems (radiography, subtraction and enhancement techniques)
- Mobile units dental units, dental panoramic tomography, cephalometry mammography
- Room layouts, control cubicles, shielding
- Primary beam, scatter, leakage
- Films, screens and film processing
- Factors affecting patient dose

Radiotherapy and Related Equipment.

- Techniques and devices used for X-ray and electron beam generation in both treatment and diagnostic equipment, including linear accelerators, superficial treatment machines, simulator equipment, and where appropriate CT and MRI scanners
- The operation and use of cobalt teletherapy and Brachytherapy equipment
- Treatment planning systems
- The operation of peripheral equipment used in this field, such as, patient verification systems, multi-leaf collimators, laser centring and outlining devices, dynamic and enhanced dynamic wedges, image generation equipment such as image intensifiers and electronic portal imaging together with their associated computer networks and peripherals
- Show awareness of Mould Room techniques, for example, lead handling procedures

Equipment Management

- Safety standards and hazards specific to ionising and non-ionising radiation, X-rays, high voltages, vacuum systems, moving and handling techniques for radiotherapy equipment, sources of information for recording and reporting
- Health and safety legislation, radiation protection and local radiation rules
- Equipment replacement programmes, business planning, costing, audit procedures, inventory control, quality control, computer and information technology applications
- Vacuum devices and techniques
- Quality control measuring equipment
- Machine operations such as, start, run-up and shut-down procedures, fault recognition
- Understand the requirement for planned preventive maintenance and the accurate recording of results
- Fault correction recording, department procedures and work instructions
- Housekeeping procedures in relation to equipment software, maintain a regular backup schedule, document and store safely copies of licensed software

Radiotherapy Quality Control.

- Beam flatness and symmetry, energy, dose rate and dose accuracy, optical alignment, diaphragm positioning
- Operation of safety interlock systems
- Beam scanning equipment using software plotting systems or hardware plotters
- Radiotherapy Quality Systems, procedures and work instructions. ISO9000:2000

Quality Management Systems Relating to Diagnostic Radiology and Radiotherapy Systems

- General requirements of a quality management system (QMS).
- Control of documentation.
- Control of records.

- Responsibility, authority and communication
- Resources
- Competence, awareness and training
- Customer focus
- Planning design and development
- Processes, inputs and outputs
- Reviews
- Verification and validation
- Identification and traceability
- Measurement, analysis and improvement
- Internal audit

CONTENTS

Rehabilitation Engineering Technology 30cp

Technology (Design and Manufacture, Materials and Equipment)

- Rehabilitation Technology Design
- Mobility, wheelchairs and Special Seating Systems
- Prosthetics and Orthotics
- Electronic Assistive Technology (EC, FES, AAC, Switches, Integrated Systems, etc)
- Architectural Barriers and Design
- Aids to Daily Living
- IT in Rehab Engineering
- Materials and Manufacturing

Measurement Technology

- Gait Measurement
- Tissue Interface Measurement
- Outcome Measurement
- Digital Photography
- Physiological Measurement
- Transducers

Clinical Practice

- Rehabilitation Engineering in The Health Service
- The RE in the professional healthcare team
- Psychosocial aspects and classification of disabilities (ICF etc)
- Assessment Methods
- Other Professional Roles(OT, PT, ST, Rehab Consultant)
- Communication With Client and Carer
- Postural Management
- Development and Prevention of Deformity

Biomechanics

- Biomechanical Analysis
- Biomechanical Models
- Biomechanics of Major Musculo-skeletal Structures
- Tissue Biomechanics
- Wheelchair Biomechanics
- Biomechanics of Seating
- Biomechanics of Gait
- Prosthetic and Orthotic Biomechanics

Disabling Pathologies

- Sensation and Sensory Loss
- Congenital Pathologies
- Diabetes
- Pressure Sores
- Spinal Pathologies
- Continence and Control
- Joint and Muscle Pathologies
- Neurological Disorders
- Ageing
- disease

Professional Studies

- Information Retrieval
- Time Management

- Report Writing
- Quality Audit
- Service Strategy
- Procurement
- Quality, Safety and Liability
- Legislative Framework
- Funding and Bidding
- Manual Handling
- Service Development

CONTENTS

Renal Technology: Renal Anatomy, Physiology and Pathology, Dialysis Techniques and Technology, Water Treatment 30cp

- Renal Anatomy, Physiology and Pathology
- Solutions and concentrations
- Equilibrium and acid dissociation
- Hydrogen ion regulation
- Electrolytes and buffers
- Chemicals in the renal environment
- Formation of urine, renal perfusion
- Glomerular filtration, tubular function; absorption and secretion
- Homeostasis
- The urinary system
- Functions of the kidney
- Metabolism in cells
- Homeostasis
- Control of body water distribution
- The role of blood
- Consequences of renal failure
- Renal disease
- Dialysis Techniques and Technology
- The fistula
- Monitoring performance
- Blood temperature and low temperature treatments
- Blood Volume monitoring
- Dialysis adequacy tools
- Low and High flux dialysis
- Middle molecule clearance
- Degenerative bone disease and dialysis complications
- Dialysis treatment options, long hour, short hour, frequent, alternate day, daily.
- Water Treatment – Municipal Systems
- Municipal water supplies
- Municipal water supply treatments
- Municipal water supply standards
- Sampling and testing

CONTENTS

Renal Technology: Water Treatment and Quality, Biochemistry, Microbiology and Virology, Modalities and Standards, Psychological and Social implications of Renal Replacement Therapy 30cp

- Water Treatment and Quality, Biochemistry, Microbiology and Virology
- Alternative Therapies and Modalities
- Daily dialysis including short hour and long hour regimes
- Peritoneal dialysis
- Haemofiltration
    - history, configuration of blood and substitution fluid circuits, differences from HD, bag and on-line systems with pre- and post dilution, Gibbs-Donnan effects, impact on sodium balance, fluid balance controlling systems, heating systems for substitution fluids, requirements on microbiological quality of the substitution fluid, efficiency assessment (mathematical description included)
- Haemodiafiltration
    - configuration of blood and dialysate circuits, differences from HF, bag and on-line systems with pre- and post dilution, fluid balance controlling systems, requirements on microbiological quality of the substitution fluid
    - efficiency assessment (mathematical description included), special HDF techniques – PFD, AFB, push-pull HDF
- Haemoperfusion
    - principles, scope of use, differences in sorbent materials, efficacy, anticoagulation, combined haemodialysis/haemoperfusion
- Plasma exchange
- Transplantation
- Diet
- Apheresis, plasmafiltration, cascade plasmafiltration
    - principles, scope of use, differences in membrane materials, efficacy, heparinisation, specific requirements on plasmafiltration technology (such as accuracy of fluid balance systems)
- Peritoneal dialysis
    - basic physiology of peritoneal transport
    - PD clearance and schedules – IPD, CAPD, NPD, TPD
    - PD cyclers – flow diagram, construction, monitoring and safety systems
- On-line technologies
    - continuous blood volume monitoring , incl. automated UF control
    - temperature and thermal balance monitoring and control
    - ionic dialysance
    - urea concentration and dialysis dose monitoring

- Renal Standards
- British Standards
- European Pharmacopoeia
- Renal Association
- AAME
- FDA

Psychological and Social implications of Renal Replacement Therapy
Pre dialysis clinic and preparation for treatment
Transplantation and transplant failure

- Communication skills to facilitate clinical investigations
- Interpersonal and listening skills
- Clinical history recording
- Communication methodology using written and oral techniques

Psychosocial aspects of disease

- Altered status awareness
- Substance abuse
- Transmissible diseases
- Chronic illness
- Links between lifestyle and health and disease
- Stress and disease
- Cognitive behaviour therapy
- Coping mechanisms
- Stress management
- Relaxation techniques
- Disability awareness
- Health promotion awareness and strategies for delivery to clients

CONTENTS

Basic Anatomy and Physiology

- Review of Common Core plus:
    - Variations in anatomy and physiology with age
    - The effects of surgical procedures which need to be considered in the planning and interpretation of radionuclide tests

Immunology

- Basic introduction to the subject and its role in the future developments of nuclear medicine procedures
- Antibodies, antigens, gamma globulin
- Resistance to infection, role in transplantation

Other Pathological Conditions

- Infection: acute, chronic, pus, abscess, differential diagnosis between abscess, cyst and tumour
- Neoplastic disease: tumours, primary and secondary, (metastases), benign and malignant tumours, assessing the extent of malignant involvement

Emergency Procedures

- Suction and maintenance of the airway
- First aid – cardiac arrest, shock, anaphylactic reaction, fits, faints, diabetic reactions
- Resuscitation equipment

Nursing Procedures

- Administration of oxygen
- Bladder catheters, surgical drains etc.
- Handling of urine and faeces, general hygienic procedures, vomiting and incontinence
- Patient preparation including the administration of drugs: potassium perchlorate, potassium iodide, diuretics, heparin
- Blood sampling, collection and handling
- Hepatitis, antigen positive patients, AIDS
- Cross infection – aerosol or gas administration systems

Administration of Radioactivity

- Checking possibility of pregnancy
- Advice to patients on breast feeding
- Identification of the patient
- Preparation of doses
- Disposal of syringes, needles and other equipment
- Types of administration; oral, intravenous, intramuscular, subcutaneous, intra-arterial
- Selection of syringes and needles
- Documentation
- Aseptic technique

Reporting Procedures

- Accidents, complaints, unexpected death
- Radiopharmaceutical adverse effects, defective products
- Spillage or loss of radioactive materials
- Informing wards and doctors of any drugs given to patients in the nuclear medicine department or any unexpected fit, arrhythmia etc.

Applied Radiation Protection

- Doses for young people
- Dealing with spills
- Contamination monitoring
- Handling urine, faeces etc.
- Measures for reducing radiation dose to staff

Elements of Clinical Audit

- The audit cycle
- Sensitivity, specificity, accuracy ROC

CONTENTS

Nuclear Medicine Technology – the Practice of Nuclear Medicine 30cp

Radiopharmaceuticals used in Nuclear Medicine

- The design of the radiopharmacy
  - Clean areas, aseptic areas
  - Requirements for aseptic procedures, laminar flow cabinets, isolators
  - Reconciliation of pharmaceutical and radiation protection requirements
  - The Guide to Good Manufacturing Practice: application to the radiopharmacy
- The types of preparation
  - Open and closed procedures
  - Production facilities necessary for the different preparation procedures
- Sterilisation techniques
  - Commonly used sterilisation techniques and their application to radiopharmaceuticals
- The operation of the radiopharmacy
  - Preparation of materials for use in the radiopharmacy, containers, tools etc.
  - Loading materials into the radiopharmacy
  - Handling techniques
  - Clothing procedures
- Maintaining and monitoring the pharmaceutical environment
  - Cleaning procedures
  - Environmental monitoring for particulate and microbial contamination
  - Operational checks on work stations
  - Record keeping: receipts, disposal, waste
- Waste disposal

Radiochemistry and Quality Control

- The chemistry of technetium
  - Valency states, techniques of reduction
  - Radionuclide generators – quality control aspects
  - Choice of reagents
  - Elution techniques
  - Molybdenum breakthrough measurements
- Radiochemical techniques
  - Chromatography: paper, thin layer, gel
  - Quality control of radiopharmaceuticals
  - Special problems of radiopharmaceuticals e.g. retrospective testing
  - Stability
  - Particle size
  - Foreign particles
  - Measurement of pH
  - Sterility, pyrogen testing
  - Radionuclide purity and its influence on radiation dose
  - Radiochemical purity and its importance
- Production of radiopharmaceuticals
  - Practical methods of producing labelled technetium products, use of commercially available kits, precautions in use, special requirements of particular products
  - Iodination, production of other radiopharmaceuticals
- Labelling of blood products
  - Special requirements for handling blood products in the radiopharmacy
  - Labelling of red blood cells with 51Cr, 99Tcm
  - Labelling of plasma with 125IHSA
  - Labelling of white cells with 99TcmHMPAO, 111In,
  - Labelling of platelets
- Selection of appropriate radiopharmaceutical

- Localisation techniques: passive and active transport, phagocytosis, cell sequestration, simple exchange
- Significance of specific activity, carrier free solutions
- Applications of specific radiopharmaceuticals
- Effect of interference from some drug therapy regimes

Perception of the Image

- Effects of noise, contrast, size and count rate
- Information content and clinical relevance
- Comparison of different types of image presentation
- Instrument generated artefacts
- Problems of dual isotope imaging
- Computer generated images, static, parametric, dynamic

In Vivo Non-imaging Techniques

- Importance of correct patient positioning
- Selection of appropriate collimation
- Thyroid uptake
- Whole body monitoring

Techniques requiring the Assay of Radioactive Samples

- Use of automatic gamma and beta counters
- Radionuclide dilution techniques
- Clearance studies
- Absorption measurements – by urine/faecal collections

The Application of Nuclear Medicine in Diagnosis

The Clinical Technologist (Nuclear Medicine) should be able to describe test protocols for radionuclide tests in common use. This should include knowledge of:-

- The radiopharmaceutical used, activity administered and route of administration, half life, beta energy
- The preparation of the patient
- The views/samples which must be obtained, dynamic protocols
- The use of any special data handling techniques or display mode
- Any special features of the study
- Possible artefacts
- Setting up the equipment – energy windows, collimation etc.

The Clinical Technologist (Nuclear Medicine) should be aware of:-

- The clinical context in which radionuclide tests may be of value, and the influence of the test results on patient management.
- The radiation dose to the patient and the risks and benefits of the particular radionuclide test to a particular patient.
- New developments in Nuclear Medicine, and the changing role of Nuclear Medicine in the diagnosis and treatment of disease and the relevant imaging modalities used in reaching a diagnosis

Skeletal Imaging

- The normal image
- The appearance of the image in primary and secondary malignancy involving bone
- Application of skeletal imaging in benign bone and joint disease, trauma and arthroplasty

Central Nervous System

- The brain scan and regional cerebral perfusion and function studies:
- The normal appearance

- Differentiation of cerebrovascular lesions from space occupying lesions
- Diagnosis of subdural haematoma
- Conditions which alter cerebral blood flow e.g. dementia, fits
- Radionuclide cisternography
- Blood flow imaging with agents which cross the blood/brain barrier e.g. HMPAO

The Endocrine System

- The thyroid gland
  - Imaging with ^{99m}Tc, ^{123}I and ^{131}I, the normal study, effect of drugs
  - Appearance of the scan in thyroid disease
  - Ectopic thyroid tissue, diagnosis of malignancy
  - Assessment of thyroid function by uptake measurement
- The adrenal glands
  - Assessment of function and localisation of tumours in the cortex or medulla
- The parathyroid glands
  - Localisation of adenomas

The Cardiovascular System

- Detection and measurement of shunts
- Cardiac output
- Myocardial imaging and its application to the detection and evaluation of myocardial Ischemic disease
- Detection of myocardial infarction
- Measurement of ejection fraction, diagnosis and assessment of ventricular aneurysm, ventricular function, wall movement
- Nuclear Medicine techniques for detection of arterial and venous disease

The Respiratory System

- Perfusion imaging, the normal image and the effect of posture, appearance in disease conditions
- Ventilation studies, use of ^{81m}Krm, ^{133}Xe gases and ^{99m}Tcm aerosols, normal images, appearance in disease conditions
- The application of perfusion-ventilation imaging in pulmonary embolus, assessment of regional lung function

The Renal Tract

- Dynamic renal studies
- The normal study
- Measurement of blood flow, diagnosis of obstruction, reflux, residual volume, diuresis renography, investigation of acute renal failure
- Assessment of the viability of renal transplants
- Static renal imaging, the normal study, applications
- Measurement of glomerular filtration rate and effective renal plasma flow

The Gastrointestinal System

- The Alimentary Tract
  - Gastric emptying studies, the normal study, effect of disease conditions, solid phase, liquid phase markers
  - Small bowel transit studies
  - Large bowel transit studies
  - Abdominal scanning in the diagnosis of Meckel's diverticulum
  - Absorption studies e.g. vitamin B_{12}, ^{14}C breath testing, SeHCAT
  - Blood loss, protein loss, sites of bleeding
- The Liver

  - Colloid liver scanning, the normal scan, detection of metastatic deposits
  - Hepatomegaly, subphrenic and liver abscesses
  - Diffuse liver disease
  - Liver blood flow
  - Hepatobiliary scanning, the normal scan, investigation of jaundice, acute cholecystitis, bile reflux
- The Pancreas
- Haematopoietic and Lymphatic Systems
  - Bone marrow imaging
  - Blood volume measurement, the normal range, effect on blood volume of disease
  - Conditions
  - Red blood cell and platelet survival
  - Applications of surface counting techniques to study iron and chromium kinetics, splenic sequestration
  - Splenic imaging, local defects, splenomegaly
  - Techniques for imaging the lymphatic system

Other Applications of Nuclear Medicine

- Localisation of inflammatory, invective and neoplastic disease e.g. ^{67}Ga, ^{111}In
- Labelled antibodies for tumour imaging

Therapeutic Applications of Radionuclides in Nuclear Medicine

- The treatment of benign and malignant disease of the thyroid gland using ^{131}I
- The treatment of diseases of the bone marrow using ^{32}P
- The treatment of synovial disease using colloidal ^{90}Y
- The treatment of adrenal tumours with ^{131}I-MIBG
- The treatment of bone metastases with ^{89}Sr
- Special problems associated with the management of patients treated therapeutically with radionuclides

CONTENTS

Radiation Physics Technology - Clinical Applications of Radiation Protection 30cp

General Principles of Radiation Protection

- Shielding, distance and time
- Justification/Optimisation/Limitation
- ICRP recommendations, ALARA principle
- Dose limits
- Euratom directives

Internal Radiation Hazards

- Annual limits on intake
- Radiotoxicity classifications

Legislation (Main Requirements)

- Ionising Radiation Regulations 1999
    - Dose limits
    - Controlled and Supervised areas
    - Classified persons
    - Training
    - Risk Assessment
    - Notification of Occurrences
    - Local Rules
    - Approved Code of Practice
    - Guidance Notes
- IR(ME)R 2000
    - Employers Procedures/Written Protocols
    - Training
    - QA Requirements
    - Diagnostic Reference Levels
    - Responsibilities – Referrers/Operators/Practitioners/Medical Physics Expert
    - Clinical Audit
- Comforters and Carers
- Radioactive Substances Act 1993
- exemption orders
- Medicines (Administration of Radioactive Substances) Regulations
- ARSAC
-
- Transport Regulations: including packaging, labelling, transport index
- Health & Safety at Work
- Enforcement and Prosecution

Clinical Sources of Radiation

- Production of X-rays
- Types of X-ray tube and design features
- X-ray generators
- Sealed sources
- Unsealed radioactive materials

Diagnostic X-ray Installations

- Radiography
- Fluoroscopy: over-couch and under-couch system, fluorography
- Computer tomography (CT) inc. multislice and electron beam CT
- Digital systems (radiography, subtraction and enhancement techniques)
- Mobile units dental units, dental panoramic tomography, cephalometry
- mammography

- Room layouts, control cubicles, shielding, warning lights/signs
- Primary beam, scatter, leakage
- Films, screens and film processing
- Factors affecting patient dose

Principles of Radiotherapy Treatment Machines

- Room design, shielding interlocks
- Linear accelerators, cobalt units, deep X-ray units
- Superficial units, simulators
- Changing radioactive sources on cobalt units

Principles of Radiotherapy Using Radioactive Materials

- Unsealed radioactive materials: storage, dispensing, disposal records, protective clothing, waste disposal, RP advice to patient
- Record keeping.
- Brachytherapy: storage, handling, records, transport of radioactive materials, preparation and cleaning
- Afterloading equipment: general principles and emergency procedures
- Storage and shielding of radioactive materials
- Environmental monitoring

Principles of the Diagnostic Use of Radioactive Materials

- Preparation of radiopharmaceuticals
- Laboratories: storage and shielding of radioactive materials,
- Dispensing and administration of doses
- Disposal of radioactive waste
- Protective clothing

Dosimetry

- Personal monitoring equipment - film badge, TLD, OSL, electrometer, pocket alarm Record keeping
- Contamination monitors, wipe tests
- Instrument types, range of probes
- Survey meters
- Ionisation chambers, Geiger counters, scintillation counters, dose and dose rate meters
- isotope calibrators
- Diagnostic X-ray QA instruments for tube output and kV
- Calibration of above instruments

Emergency Procedures

- Over-exposure of staff
- Notification of appropriate authority
- Annual dose limits,
- Over-exposure of patients
- Equipment check
- Internal contamination
- Assessment of dose, blocking agents
- Spillage of RA materials
- Containment, record keeping, disposal of waste
- Decontamination of personnel & equipment methods and substances used
- Loss of, or damage to, radioactive sources
- Contingency plans, including
    - Written procedures
    - Suitable equipment
    - Protective clothing and other devices

    - Personal dosimeters
- Criticality alarms
- Emergency services
- National Arrangements for Incidents involving Radioactivity (the NAIR scheme for incidents in public places)
- Civil nuclear emergencies

Quality Systems

- Principles of Quality Assurance, quality control, quality improvement, quality systems
- Accreditation of calibration laboratories(NAMAS)

CONTENTS

Radiation Physics Technology: Practical Applications 30cp

Organisation of Radiation Protection in Hospitals

- Appointed officers, roles and responsibilities
- Radiation Protection Advisor, Radiation Protection Supervisor, Medical Physics Expert
- Appointed Doctor, employers, Radiation Safety Committee
- Identifying controlled and supervised areas
- Dose rates, warning notices
- Designation of classified persons
- Dose levels, monitoring (internal and external)
- Local rules
- Description of duties, system or work

Personnel Dose Monitoring

- Film monitoring
- TLD monitoring
- OSL Monitoring
- Calibrations
- Pocket dosimeters
- Operation of a personal monitoring service and approved dosimetry service
- Whole body, extremities, eyes

Performance Testing of Diagnostic X-ray Equipment

- X-ray tube and generators (conventional, CT, dental mammography):
    - Leakage, focal spot, light beam alignment, timer, tube kilovoltage output
    - Half value thickness and filtration
- Radiographic automatic exposure controls:
    - Dose to receptor under varying conditions
- Conventional tomography:
    - Cut height, swing angle
- Image intensifier fluoroscopy:
    - TV signal, contrast, resolution, geometrical distortion, input dose rate, automatic brightness control
    - Image Intensifier fluorography and other spot imaging:
    - Resolution, dose per frame
- Computerised Tomography:
    - Imaged and Irradiated slice width, low and high contrast resolution, noise, CT number uniformity and linearity, cursor accuracy
    - Performance testing programmes.

Patient Doses

- Factors affecting patient dose:
- kV, mAs, FFD, filtration, field size
    - Automatic exposure controls, grids, film and screen sensitivity
    - Processing, repeat films, shielding (gonads etc.), image quality, condition of image receptors
    - Digital/non-digital, filter materials (aluminium copper, k edge)
- Patient dose measurements:
    - National protocol, entrance surface dose, dose area product, doses at other points using TLD, foetal dose
- Diagnostic Reference Levels

Shielding Calculations and Design Features

- Protection of staff and general public
- Planning controlled and supervised areas

- Shielding materials, including lead, concrete, brick, barytes plaster
- Diagnostic X-ray rooms:
    - Doors, walls, floors, control cubicles, warning lights and signs;
- Mammography, CT, dental clinics (intra-oral, panoramic radiography, cephalometry)
- Radiotherapy treatment rooms (basic principles):
    - Walls, floor, roof; choice of materials, maze design,
    - Interlocks, warning lights
- Linear accelerators, cobalt unit, deep X-ray, superficial
- Simulator
- Afterloading (basic principles):
    - Occupancy, emergency equipment, warning signs and signals
- Autotimers
- Nuclear Medicine
    - Radiopharmacy storage, waste storage and disposal, sample measurement, decontamination
    - Surface materials and finishes, enclosures and extract systems, laminar flow cabinets

Clinical and Laboratory Procedures

- Preparation and dispensing
- Personal protection, contamination control
- Changing facilities, protective clothing
- Administration to patients
- Preparation of patient, instruction to patient
- Syringe shields, gloves, disposal of syringes
- Radioactive waste disposal
- Regulations, authorisation certificates, storage
- Environment Agency/Scottish Environmental Protection Agency
- Disposal of patient waste products
- Procedures in wards and operating theatres
- Preparing and cleaning clinical sources
- Storage and transport of radioactive materials
- Records of radioactive materials, dispensing
- Patient administrations, patient doses, waste disposal

Survey Procedures

- Diagnostic X-ray departments, including:
    - Size of room, doors, walls, windows etc., testing barriers
    - Testing protective clothing: aprons, gloves, spectacles, thyroid shields etc.
    - Control cubicle design and lead equivalence
    - Film storage, dark room
    - Occupancy of surrounding areas
    - Local rules
    - Exposure control
- Dental X-ray rooms and clinics:
    - Size of room, surrounding occupancy
    - Patient protective clothing
    - Local rules, exposure control
- Wards, operating theatres, etc.
- Radiotherapy rooms (basic principles):
    - Efficiency of barriers, maze, interlocks, etc.
    - Simulators
- Mould rooms (basic principles):
    - Safes, remote handling devices, dose rates, local rules
    - Brachytherapy patients: doses in their vicinity

- Nuclear Medicine:
    - Syringe shields, waste storage and disposal,
    - Dispensing area: clean/dirty area, protective clothing,
    - Fume cupboards, surface coverings, sinks, hand monitors, decontamination procedures, local rules
    - Laboratories:
    - Surface coverings, drip trays, safe storage space, fume cupboards, waste disposal, sinks, syringe shields
    - Changing areas, contamination monitoring equipment, wipe tests, local rules, reports

Practical Use and Applications of Instruments

- Primary standards and national system
- Calibration of instruments against secondary standards
- Checking instruments for consistency, comparison and accuracy
- Storage

Record Keeping

- Registration of use of radioactive materials
- Authorisations for accumulation and disposal
- Administration of Radioactive Substances Advisory Committee (ARSAC) certificates
- Staff: dose records, health records
- Nuclear Medicine
    - Activity incoming, dispensed, injected and disposed contamination monitoring, leakage tests
    - Equipment
    - Calibration data
    - Measurements of machines, barriers, surveys

Procedures for Dealing with Emergency Situations

- Procedure for Radioactive Patients Leaving Hospital
    - Patient dose rate
    - Removal of temporary implants
    - Information card with travel dates, work dates, and personal contact dates
- Death of Radioactive Patients
    - Removal of implants
    - Informing pathologists etc. of precautions for post-mortems
    - Dose levels for embalming, burial and cremation

CONTENTS

Radiotherapy Physics Technology - Anatomy, Physiology, Pathology, Radiobiology & Patient Care 30cp

Clinical Evaluation including Application of Medical Imaging to Radiotherapy

- Referrals
- Clinical evaluation - pathology, staging, investigations
- Therapy options
    - Radiotherapy method
    - External beam - photon and electron energy selection
    - Use of electron beams
    - Superficial and othovoltage
    - Cobalt teletherapy
    - Brachytherapy
    - Radio-isotope therapy
- Aim of radiotherapy - radical, adjuvant, palliation
- Follow-up
- Imaging
    - Sectional anatomy from CT and MRI
    - Functional imaging - PET & SPECT

Radiobiology Related to Radiotherapy

- Linear energy transfer & radiobiological effect
- Cell survival curves - shape, cell kill, chromosomes and cell division
- Dose response relationship
- Radiosensitivity
    - Clonogenic assays
    - Oxygen enhancement
    - Radiosensitisers and radioprotectors
- Tumour system
    - Tumour growth
    - Cure
    - Cell survival
    - TCP/NTCP - therapeutic ratio
- Dose – time relationship
    - Damage classification
    - Fractionation
    - The four 'R's of radiobiology
    - Inverse dose-rate effect
    - Low dose versus continuous
- Radiation pathology -acute and late effects
- Radiation carcinogenesis
- Radiobiological models – linear quadratic

Tumour Pathology

- Anatomy, pathology, lymphatic drainage and associated critical structures:
    - Head and neck
    - Central nervous system
    - Pituitary
    - Thorax
    - Breast
    - Abdomen
    - Pelvis
- Hodgkin's Disease
- Leukaemia
- Extremities
- Metastases

Treatment Planning Considerations

- Prescribed Dose
    - ICRU dose reference point
    - Dose variation
- Target delineation
    - Gross tumour volume
    - Clinical target volume
    - Internal margin
    - Set-up margin
    - Planning target volume
    - Organs at risk
    - Planning
    - Organs at risk volume
    - Dose limits
- Treatment techniques (site specific)
    - Standard/non-standard field arrangements
- Typical tissue heterogeneities

Patient Care in the Mould Room

- Patient instruction and consent
- Determining the appropriate position
- Children
- Psychological constraints
- Physiological constraints
- Anaesthetised patients
- Beards
- tracheostomies
- Kyphosis and scoliosis

CONTENTS

Radiotherapy Physics Technology - Practice of Radiotherapy Physics 30cp

Positioning and Immobilisation

- Isocentric mounting
    - Laser alignment – axis lights
- Front and back pointers
- Patient positioning
- Immobilisation (site specific)
    - Beam direction shells (BDS)
    - Impression materials
    - BDS materials
    - Thermoplastic immobilisation devices
    - Adhesives
    - Patient/couch registration devices

Localisation

- Surface contouring
- Use of orthogonal radiographs and shift radiographs
- CT localisation
    - Inhomogeneities
    - Surface contours and organs at risk
- Use of MRI & image fusion
- Data Transfer
- Planning target volume – margins
- Organs at risk (critical organs and dose constraints)

Dose Planning and Display

- Treatment Planning algorithms including pencil beam, collapsed cone and Monte Carlo
- Dose distribution computation
- Computer Planning
    - 2-D and 3-D plans
    - Comparison of CT and non-CT plans
    - Beam's eye view
- Plan Evaluation
    - Isodose distributions
    - Dose volume histograms
- Conformal planning
- Optimisation including inverse planning techniques and IMRT
- Forward planned segmented field techniques

Beam Modification

- Collimation - asymmetric jaws
- Beam shaping and shielding
    - Multi-leaf collimators
    - Shielding block construction
    - Partial transmission blocks
    - Transmission blocks
- Bolus and compensators
    - Indications for use
    - Types of compensators
    - Design and construction of compensators,
    - Compensator materials
- Wedges: mechanical, dynamic/virtual

Dose Calculations

- Dose prescription

- Phantom Scatter Factors
    - Back Scatter Factor & Peak Scatter Factor
- Head scatter
- Radiation Output
    - Relative output factors
    - Transmission factors – wedge
    - Shadow tray
- Computation of treatment time/set dose
- Effect of inhomogeneities

Verification

- Positional accuracy and tolerances
    - Simulator verification
    - Portal films
    - Electronic portal imaging
    - CT verification
    - Image comparison tools
- Dosimetric accuracy - patient dose monitoring
- Record and verify systems

Image guided radiotherapy

- Principles of
- Modifications to treatment delivery

Gated radiotherapy

- Principles
- Impact on treatment delivery

Dose Measurement

- Selection of appropriate dosemeter
- Absolute dose measurement
    - Output measurements
    - Traceable
- Relative dose measurement
- Beam data acquisition
- Patient dosimetry – diodes, TLD, EPIDs
- Electron dosimetry
- Brachytherapy source calibration

Operation of Treatment Equipment

- Controls, operation and emergency procedures for:
    - Very low/low/medium energy x-ray equipment
    - Linear Accelerator - photon/electron beam generation
    - Cobalt teletherapy unit
    - Treatment simulator
    - CT-simulator

Electron Beam Therapy

- Beam shaping
    - Collimation
    - Shields and cut-outs
    - Customised shaped blocks
    - Internal shields, back scatter
    - Eye shields (external)
- Monitor unit calculation

SXT Dosimetry

- Back scatter factors
- Lead cut-outs
- Applicators
- Eye shields (internal/external)

Radiation Protection

- Structural shielding
    - External beam
    - Brachytherapy
- Measures for reducing radiation dose to staff during brachytherapy
- Source handling and storage
- Procedures for radioactive patients leaving hospital
- Death of radioactive patients - removal of implants

Quality Control & Quality Assurance

- Quality systems
    - ISO 9000
    - QART
    - Quality control procedures
    - Work instructions/protocols,
    - Reporting procedures
    - Non-conformances and concessions
    - Record keeping
- Treatment Machine QC Program - logic, method and frequency
- Quality control of external beam radiotherapy equipment
- Quality control of radiotherapy simulator
- Quality control of CT and MRI
- Quality control for brachytherapy equipment and systems
- Quality control for treatment planning systems
- Treatment plan and radiotherapy prescription calculation checks
- Quality control of dosimetry systems

Brachytherapy Preparation and Planning

- Units of measurement
- Source calibration
- Calculation of dose distributions
    - Interstitial - Paris Method, computer modelling, pre-planning, post implant planning, fractionation
    - Intracavitary/intraluminal - Manchester - reference points, computer modelling
    - Surface applicators – Patterson and Parker – source distributions, fractionation

CONTENTS

Clinical Technologist Core Competence

1. Health & Safety
   a. Assess risks associated with work activity
   b. Develop and maintain health, safety and security practices in the workplace
   c. Demonstrate and encourage health, safety and security practices in the workplace
   d. Report incidents associated with work activity
2. Research & Development
   a. Conduct investigations in selected research and development topic
   b. Collate and analyse data
   c. Interpret results of research and development activities
   d. Document and record conclusions and recommendations of research and development activities
   e. Present findings of research and development activities in written form
   f. Present findings of research and development activities orally
3. Patient/client care
   a. Prepare information and instructions of issue to patients prior to attendance
   b. Receive patients and carers
   c. Make initial assessment on patient readiness to undertake planned procedures
   d. Measure and record physical characteristics and condition of patient
   e. Support movement and handling of patients during procedures
   f. Monitor clinical condition of patients during procedures
   g. Advise and inform patients on next action
   h. Respond to emergency situations during investigations and procedures
   i. Prepare patient for investigation or procedure
   j. Maintain information on patients and samples for audit
4. Management
   a. Demonstrate an awareness of the functional structure of the organisation in which they are employed and their place in it
   b. Demonstrate and awareness of the responsibilities of associated disciplines and the inter-relation between fellow professionals
   c. Organise their time effectively
   d. Demonstrate the ability to collect, collate and pass on information efficiently and effectively
   e. Understand replacement programs, business planning, costing, audit procedures, inventory control, quality control, computer and information technology applications
   f. Demonstrate an ability to deal with equipment suppliers and manufacturers
   g. Demonstrate the ability to maintain clinical and/or equipment records
   h. Demonstrate the ability to investigate adverse occurrences and facilitate warranty claims
   i. Demonstrate the ability, where appropriate, to monitor maintenance and repair contractors
5. Communication Skills
   a. Communicate effectively with clinical and professional colleagues understanding and practising the principles of confidentiality
   b. Present material effectively through reports, presentation and seminars
   c. Discuss appropriately, with patients or clients, procedures being undertaken
   d. Understand the confidential nature of patients' illness and treatment, or clients' disabilities
   e. Demonstrate an ability to work within a team
   f. Demonstrate ability to report back from manufacturers training courses
   g. Communicate effectively with multidisciplinary teams
   h. Demonstrate the ability to teach, train and assess staff where appropriate.
6. Quality Assurance
   a. Discuss the applicability of quality systems within their Department
   b. Understand the principles of quality systems and how they are applied by manufacturers, suppliers and other Departments

   c. Demonstrate the ability to provide quality assured, management information where appropriate
7. Information Management and Technology
   a. Understand the procedures for starting and stopping common computer systems, for example personal computers, and follow procedures for specialist local systems
   b. Understand the differences between the various operating systems used within the workplace and how to launch programs from them
   c. Understand the uses of removable media, and be capable of selecting and using the correct media for a particular task and be aware of appropriate handling guidelines
   d. Understand the reasoning behind backup policies
   e. Understand the concept of file systems and directories. Be aware of the need to maintain clear organisation of user data, program files and system files
   f. Understand the roles of word processor, spreadsheet and database packages and be able to determine the correct package to use for a particular task
   g. Understand and make use of electronic communications links (for example, electronic mail, web browsing) and be aware of their role within the NHS (for example, NHSNet, structured e-mail)
   h. Understand the key principles of the Data Protection Act
   i. Understand software licensing principles and how their compliance may affect a healthcare organisation

Clinical Practice Placement Modules, Years 1 & 2. Medical Engineering Technology

1. Manage equipment on loan to the organisation
   a. Ensure the completion of appropriate indemnity documentation
   b. Establish the current service status of the equipment and date of next service due
   c. Carry out and record acceptance and safety testing
   d. Withdraw loaned equipment from use and return to the provider at the end of the loan period
2. Commissioning and install medical equipment for clinical use
   a. Install installation of the equipment under supervision
   b. Confirm that all required accessories, ancillary devices and instruction manuals and service manuals are available and ready for use
   c. Complete all acceptance checks and record results
   d. Register equipment on appropriate database
   e. Use appropriate test and measurement equipment
   f. Confirm equipment is operating within expected configuration, performance and safety parameters
3. Maintain medical equipment for clinical use for a basic range of medical devices including suction, nebulisers, spirometers, infusion devices, temperature and blood pressure monitoring, basic ECG recorders
   a. Make informed use of the detailed technical information provided by the manufacturers' service manuals
   b. Use appropriate test equipment and service tools
   c. Confirm test equipment is correctly calibrated for maintenance and repair activities
   d. Reference the correct protocol for type and range of equipment
   e. Complete planned preventive maintenance to specified schedule
   f. Diagnose faults and determine appropriate action
   g. Repair equipment
   h. Complete all records accurately and store in correct location for future use
   i. Inform users of the progress of repairs and advise on contingency arrangements
   j. Inform users of reasons for fault, action taken and how to avoid re-occurrence
   k. Seek advice or support when required maintenance activity falls outside own level of expertise
4. Decommission and dispose of equipment
   a. Decommission and dispose of equipment by methods appropriate to identified risks in accordance with local procedures
   b. Document the decommissioning and disposal of equipment in accordance with local procedures
5. Record and manage equipment and service history information
   a. Enter data into a database
6. Audit and report on current use and effectiveness of medical equipment – for a basic medical device
   a. Develop and use audit and reporting tools
   b. Relate to current governance requirements such as controls assurance
   c. Draw together audit and other data into appropriate reports
7. Design construct and test prototypes for novel medical equipment for a simple circuit design
   a. Specify, design and construct equipment to meet appropriate safety standards
   b. Verify and validate prototypes; verify that specification has been met and validate that this satisfies intended purpose
8. Clinically trial novel medical equipment in relation to the circuit developed in section 7
   a. Carry out experiments
   b. Critically evaluate results of trials
   c. Report and/or publish results

1. Evaluate new medical equipment for clinical use
   a. Establish equipment performance parameters and their relevance to clinical need
   b. Assess risks associated with equipment use
   c. Assess training requirements of proposed users
   d. Obtain sufficient data on operation, capabilities and limits of equipment to enable decision on safety and effectiveness of use in context
   e. Design evaluation procedures relevant to the equipment under consideration
   f. Document the results of the evaluation in an appropriate format
2. Manage equipment on loan to the organisation for a broad range of equipment
   a. Ensure the completion of appropriate indemnity documentation
   b. Establish the current service status of the equipment and date of next service due
   c. Establish the responsibility for the provision of consumables during the loan
   d. Ensure users are made aware of the need for appropriate training
   e. Carry out and record acceptance and safety testing
   f. Withdraw loaned equipment from use and return to the provider at the end of the loan period
3. Procure medical equipment for clinical use
   a. Produce a specification at level of detail relevant to complexity of the equipment, the intended purpose and the purchasing process
   b. Establish clear and relevant evaluation criteria for equipment and suppliers
   c. Evaluate offers against agreed evaluation criteria
4. Commissioning and install medical equipment for clinical use
   a. Install installation of the equipment under supervision
   b. Confirm that all required accessories, ancillary devices and instruction manuals and service manuals are available and ready for use
   c. Complete all acceptance checks and record results
   d. Register equipment on appropriate database
   e. Use appropriate test and measurement equipment
   f. Confirm equipment is operating within expected configuration, performance and safety parameters
5. Maintain medical equipment for clinical use for the full range of medical devices including suction, nebulisers, spirometers, infusion devices, temperature and blood pressure monitoring, complex ECG recorders, oxygen analysers, carbon dioxide monitors, electrosurgery equipment, blood gas analysers, ventilators, endoscopic systems, dialysis equipment, physiotherapy, Audiology and ophthalmology equipment, lasers.
   a. Make informed use of the detailed technical information provided by the manufacturers' service manuals
   b. Use appropriate test equipment and service tools
   c. Confirm test equipment is correctly calibrated for maintenance and repair activities
   d. Reference the correct protocol for type and range of equipment
   e. Complete planned preventive maintenance to specified schedule
   f. Diagnose faults and determine appropriate action
   g. Repair equipment
   h. Complete all records accurately and store in correct location for future use
   i. Inform users of the progress of repairs and advise on contingency arrangements
   j. Inform users of reasons for fault, action taken and how to avoid re-occurrence
   k. Seek advice or support when required maintenance activity falls outside own level of expertise
6. Monitor contractors performance for equipment supply, maintenance, and support.
   a. Confirm that the equipment and all ancillary devices and accessories are available and ready for use when equipment is placed in the clinical environment.
   b. Confirm that equipment is operating within expected performance and safety parameters.

c. Document the performance of the contractor against agreed measures to enable a decision on compliance with the contract to be made.
d. Obtain external support from those with specialist knowledge when this is required.
e. Take appropriate action if a lack of performance on the part of the contractor is likely to impact on the care delivered in the clinical environment

7. Decommission and dispose of equipment
   a. Establish criteria for withdrawal of equipment from service
   b. Establish the presence and category of hazardous materials and the risks associated with their disposal
   c. Determine the most effective option for safe and compliant disposal of equipment and associated hazardous substances
   d. Decommission and dispose of equipment by methods appropriate to identified risks in accordance with local procedures
   e. Document the decommissioning and disposal of equipment in accordance with local procedures
8. Investigate and manage actual and potential incidents or hazards involving medical equipment
   a. Initiate immediate action in order to ensure safety and prevent further harm
   b. Quarantine equipment and scenes in order to preserve evidence
   c. Collect and analyse available evidence to determine the possible causes of the incident
   d. Seek other appropriate expert advice where necessary
   e. Maintain records of incidents
   f. Identify actions required
   g. Implement and record actions required
9. Record and manage equipment and service history information
   a. Enter data into a database
   b. Adapt the database to meet local needs
   c. Administer the system and database
   d. Manage access rights to the database
10. Provide advice and support on the use and availability of medical equipment for a simple medical device
   a. Design or source appropriate training material
   b. Deliver relevant training
11. Audit and report on current use and effectiveness of medical equipment
   a. Develop and use audit and reporting tools
   b. Relate to current governance requirements such as controls assurance
   c. Draw together audit and other data into appropriate reports
12. Design construct and test prototypes for novel medical equipment
   a. Specify, design and construct equipment to meet appropriate safety standards
   b. Verify and validate prototypes; verify that specification has been met and validate that this satisfies intended purpose
   c. Design package and label equipment suitable for its intended purpose and environment
   d. Design to meet decontamination requirements and procedures
   e. Develop and implement test and/or calibration procedures
   f. Develop procedures for evaluating safety
   g. Compile appropriate technical and user documentation to meet local and statutory requirements
   h. Carry out risk assessment to meet the requirements of applicable standards
13. Clinically trial novel medical equipment in relation to the circuit developed in section 12
   a. Write appropriate evaluation protocols
   b. Secure ethical approval for equipment and trials if appropriate
   c. Carry out experiments
   d. Critically evaluate results of trials
   e. Report and/or publish results

Clinical Practice Placement Modules, Years 1 & 2. Radiation Engineering Technology

1. Understand and comply with the local rules for work with ionising radiation within the X-ray or Radiotherapy department
2. Identify relevant safety features in a diagnostic X-ray or Radiotherapy room
3. Participate in the commissioning and installation of X-ray or Radiotherapy equipment
    a. Participate in the installation of equipment under supervision
    b. Confirm that all required accessories, ancillary devices and instruction manuals and service manuals are available and ready for use
    c. Participate in acceptance checks and record results
    d. Register equipment on appropriate database
    e. Use appropriate test and measurement equipment
    f. Confirm equipment is operating within expected configuration, performance and safety parameters
4. Maintain X-ray or Radiotherapy equipment for clinical use
    a. Make informed use of the detailed technical information provided by the manufacturers' service manuals
    b. Use appropriate test equipment and service tools
    c. Confirm test equipment is correctly calibrated for maintenance and repair activities
    d. Reference the correct protocol for type and range of equipment
    e. Complete planned preventive maintenance to specified schedule
    f. Diagnose faults and determine appropriate action
    g. Repair equipment
    h. Complete all records accurately and store in correct location for future use
    i. Inform users of the progress of repairs and advise on contingency arrangements
    j. Inform users of reasons for fault, action taken and how to avoid re-occurrence
    k. Seek advice or support when required maintenance activity falls outside own level of expertise
5. Decommission and dispose of equipment
    a. Decommission and dispose of equipment by methods appropriate to identified risks in accordance with local procedures
    b. Document the decommissioning and disposal of equipment in accordance with local procedures
6. Record and manage equipment and service history information
    a. Enter data into a database
7. Measure the performance characteristics of an X-ray set
    a. Calibrate an x-ray survey meter for a particular radiation energy
    b. Measure radiation output and consistency
    c. Measure kV under various exposure conditions
    d. Measure focal spot size
    e. Use optical sensitometry to calculate film characteristics
8. Measure and record levels and characteristics of radiation
    a. Select appropriate monitor or dosemeter for the type(s) of radiation to be measured
    b. Ensure selected apparatus is in working order and within calibration.
    c. Perform the full range of measurement activities specified.
    d. Record the results of measurements accurately and in correct format.
    e. Make results available to appropriate person within specified timescales
9. Quality assure x-ray imaging equipment on a range of basic X-ray equipment, and obtain supervised experience on more complex X-ray equipment (AEC, tomography etc.)
    a. Select routine tests to perform.
    b. Perform tests at recommended intervals, on the equipment to ascertain whether baselines established during the commissioning tests are being maintained.
    c. Analyse results and compare against expected performance, standards and guidance.

   d. Identify faults/poor performance.
   e. Recommend actions.
   f. Liase with other professionals who undertake quality control and make use of test data

10. Quality control radiotherapy systems
    a. Apply agreed quality control measures and methods
    b. Check equipment is operating within agreed tolerances
    c. Use an auditable recording and document system
    d. Handover management and on-going evaluation to relevant, suitable trained personnel
    e. Take or initiate appropriate corrective action in respect of non-compliance

Clinical Practice Placement Modules, Years 3 & 4. Radiation Engineering Technology

1. Carry out a radiation safety survey of a new x-ray facility to include tube leakage, effectiveness of room structure
2. Estimate the total filtration of an x-ray tube assembly
3. Quality assure a full range of x-ray imaging equipment
    a. Select routine tests to perform.
    b. Perform tests at recommended intervals, on the equipment to ascertain whether baselines established during the commissioning tests are being maintained.
    c. Analyse results and compare against expected performance, standards and guidance.
    d. Identify faults/poor performance.
4. Participate in the commissioning and installation of X-ray or Radiotherapy equipment
    a. Install X-ray and Radiotherapy equipment under supervision
    b. Confirm that all required accessories, ancillary devices and instruction manuals and service manuals are available and ready for use
    c. Complete all acceptance checks and record results
    d. Register equipment on appropriate database
    e. Use appropriate test and measurement equipment
    f. Confirm equipment is operating within expected configuration, performance and safety parameters
5. Maintain X-ray or Radiotherapy equipment for clinical use
    a. Make informed use of the detailed technical information provided by the manufacturers' service manuals
    b. Use appropriate test equipment and service tools
    c. Confirm test equipment is correctly calibrated for maintenance and repair activities
    d. Reference the correct protocol for type and range of equipment
    e. Complete planned preventive maintenance to specified schedule
    f. Diagnose faults and determine appropriate action
    g. Repair equipment
    h. Complete all records accurately and store in correct location for future use
    i. Inform users of the progress of repairs and advise on contingency arrangements
    j. Inform users of reasons for fault, action taken and how to avoid re-occurrence
    k. Seek advice or support when required maintenance activity falls outside own level of expertise
6. Monitor contractors performance for equipment supply, maintenance, and support.
    a. Confirm that the equipment and all ancillary devices and accessories are available and ready for use when equipment is placed in the clinical environment.
    b. Confirm that equipment is operating within expected performance and safety parameters.
    c. Undertake appropriate handover procedures
    d. Document the performance of the contractor against agreed measures to enable a decision on compliance with the contract to be made.
    e. Obtain external support from those with specialist knowledge when this is required.
    f. Take appropriate action if a lack of performance on the part of the contractor is likely to impact on the care delivered in the clinical environment
7. Decommission and dispose of equipment
    a. Establish criteria for withdrawal of equipment from service
    b. Establish the presence and category of hazardous materials and the risks associated with their disposal
    c. Determine the most effective option for safe and compliant disposal of equipment and associated hazardous substances
    d. Decommission and dispose of equipment by methods appropriate to identified risks in accordance with local procedures

   e. Document the decommissioning and disposal of equipment in accordance with local procedures
8. Investigate and manage actual and potential incidents or hazards involving medical equipment
   a. Initiate immediate action in order to ensure safety and prevent further harm
   b. Quarantine equipment and scenes in order to preserve evidence
   c. Collect and analyse available evidence to determine the possible causes of the incident
   d. Seek other appropriate expert advice where necessary
   e. Maintain records of incidents
   f. Identify actions required
   g. Implement and record actions required
9. Record and manage equipment and service history information
   a. Enter data into a database
10. Specify and design treatment machine accessories and modifications to assist with radiotherapy
   a. Design treatment machine accessories that meet the needs of a particular treatment
   b. Use relevant computer planning tools and techniques to aid design and production where appropriate
   c. Access support from a multi-disciplinary team
   d. Assess safety issues relating to such devices
11. Quality control radiotherapy systems
   a. Apply agreed quality control measures and methods
   b. Check equipment is operating within agreed tolerances
   c. Use an auditable recording and document system
   d. Handover management and on-going evaluation to relevant, suitable trained personnel
   e. Take or initiate appropriate corrective action in respect of non-compliance
12. Conduct definitive calibration of radiation delivery and measurement devices
   a. Determine if Definitive Calibration is necessary
   b. Carry out Definitive Calibration following the current legal guidance
   c. Assess the readiness of the equipment for a Definitive Calibration to be carried out.
   d. Complete the necessary records and ensure that a second qualified person carries out the necessary checks
   e. Risk assess clinical use of equipment

1. Maintain rehabilitation equipment for clinical use for a basic range of assistive devices, for example, powered wheelchairs, manual wheelchairs and environmental control systems.

    a. Make informed use of the detailed technical information provided by the manufacturers' service manuals
    b. Use appropriate test equipment and service tools
    c. Confirm test equipment is correctly calibrated for maintenance and repair activities
    d. Reference the correct protocol for type and range of equipment
    e. Complete planned preventative maintenance to specified schedule
    f. Diagnose faults and determine appropriate action
    g. Repair equipment
    h. Complete all records accurately and store in correct location for future use
    i. Inform users of the progress of repairs and advise on contingency arrangements
    j. Inform users of reasons for fault, action taken and how to avoid re-occurrence
    k. Seek advice or support when required maintenance activity falls outside own level of expertise

2. Decommission and dispose of equipment

    a. Decommission and dispose of equipment by methods appropriate to identified risks in accordance with local procedures
    b. Document the decommissioning and disposal of equipment in accordance with local procedures

3. Manufacture of assistive devices to specification

    a. Review specification for manufacturing viability
    b. Correctly interpret the specification for the assistive device
    c. Identify existing components for suitability
    d. Determine those aspects of specification which relate to modification or adaptation of existing devices
    e. Monitor and liaise with all individuals or agencies involved in the production process
    f. Incorporate relevant testing, inspection and risk management throughout the manufacturing and commissioning process
    g. Document and record manufacture in accordance with relevant procedures
    h. Confirm that final product meets design specification and required performance parameters
    i. Produce and assemble components to meet specification
    j. Test product against specification prior to fitting with individual patient and confirm performance within expected parameters

1. Monitor contractors performance for rehabilitation equipment supply, maintenance, and support.

    a. Confirm that the equipment and all ancillary devices and accessories are available and ready for use when equipment is placed in the clinical environment.
    b. Confirm that equipment is operating within expected performance and safety parameters.
    c. Document the performance of the contractor against agreed measures to enable a decision on compliance with the contract to be made.
    d. Obtain external support from those with specialist knowledge when this is required.

    e. Take appropriate action if a lack of performance on the part of the contractor is likely to impact on the care delivered in the clinical environment

2. Investigate and manage actual and potential incidents or hazards involving rehabilitation equipment

    a. Initiate immediate action in order to ensure safety and prevent further harm
    b. Quarantine equipment and scenes in order to preserve evidence
    c. Collect and analyse available evidence to determine the possible causes of the incident
    d. Seek other appropriate expert advice where necessary
    e. Maintain records of incidents
    f. Identify actions required
    g. Implement and record actions required

3. Determine individual capabilities and needs for assistive technology

    a. Confirm the reason for referral, clinical need, objectives of assessment goals of individual and carers
    b. Confirm the nature, type and extent of measurements that will be required to complete the assessment
    c. Take action to resolve or manage the non-attendance of other members of relevant multi-disciplinary team
    d. Take accurate, relevant and sufficient measurements to assist with specification or decision on alternative solutions
    e. Identify the scope and limitations of the individual's function, capacity and social interaction that will influence the type, nature, design or use of intended solution
    f. Sensitively exchange relevant information with users and carers and using terminology which aids communication
    g. Seek advice and support from relevant people to inform judgements and decisions
    h. Produce complete and accurate records of the assessment process and results
    i. Report on the assessment, relating results directly to the agreed objectives and referral questions raised
    j. Propose suitable action where the original referral or information proves to be inappropriate or where information collected raises additional issues

4. Prescribe solutions to meet individual needs

    a. Correctly interpret data from individual user assessment and confirm objectives
    b. Resolve any apparent discrepancies or omissions in data provided, referring to relevant colleagues or user
    c. Access relevant information from available sources to investigate possible options
    d. Draw on previous cases of similar clinical conditions or user needs to establish suitability of options considered

e. Evaluate all data to determine relevance to proposed options and associated risks
f. Generate a range of suitable options clearly differentiating between appropriate and inappropriate factors
g. Prioritise and weight options against needs, availability, cost and user/carer preferences
h. Consider all factors, including future interventions, which influence selection of suitable solutions
i. Report at sufficient level of detail with recommendations for prescription for type and purpose of solution
j. Determine the required clinical review period, including cases where no intervention is prescribed

5. Specify assistive technology to meet prescription
    a. Review options generated with key stakeholders and reach agreement on optimum solution
    b. Ensure specification has taken full account of clinical, personal and environmental factors and risks affecting use and effectiveness
    c. Liaise with other stakeholders to ensure that all current influencing factors have been taken into consideration
    d. Interpret information correctly to assist with informed decision on clinically acceptable solution
    e. Produce a design specification which meets prescription and accommodates manufacturing constraints by those who will manufacture or implement
    f. Ensure notation of special requirements which may relate to personal or environmental factors influencing use of the assistive technology by the patient
    g. Ensure integration of the specified solution with the user's overall treatment plan, including agreement of trial periods and reviews, which may be required.
    h. Recommend appropriate manufacturing process
    i. Produce engineering drawings

6. Commission and manage assistive devices for individual use
    a. Select suitable location for commissioning devices
    b. Confirm suitability of operation and/or fit of the device within expected performance parameters and prescription
    c. Confirm effective operation of the device within the user environment (actual or simulated)
    d. Instruct user and carers in the safe use, transport and general maintenance of the device and confirm understanding
    e. Where required, restrict device functions for initial or trial periods to enable familiarity and ensure safety
    f. Agree relevant trial and review periods to co-ordinate with user treatment plan and develop full capabilities in use of the device
    g. Confirm usage patterns, including frequency and duration based on clinical considerations
    h. Where adjustments are required, obtain relevant measurements and other data
    i. Make minor adjustments to achieve required performance
    j. Arrange for modification to be undertaken
    k. Confirm that user and carers have relevant documentation, are confident and comfortable with use of the device and understand what further action may be taken
    l. Identify and document fully the device(s) issued in order to facilitate traceability
    m. Document and report the process and outcomes of commissioning, including user training
    n. Ensure that arrangements for further action are implemented.
    o. Document maintenance periods and requirements for device management
    p. Establish and agree responsibility for equipment issued
    q. Ensure that there is in place a mechanism for detecting and reporting device failure
    r. Establish mechanisms for on-going device management

Clinical Practice Placement Modules, Years 1 & 2. Nuclear Medicine Technology

On completion of the training the student will be able to:

A. Justify the procedure in terms of clinical condition and relevant medical history in relation to why the procedure is being performed
B. Demonstrate effective communication so that the patient is appropriately informed of the procedure
C. Deliver appropriate patient care in relation to the examination or treatment
D. Select and utilise the equipment safely and efficiently
E. Competently undertake the appropriate nuclear medicine technique consistent with the patients' clinical condition
F. Evaluate and implement the appropriate radiation protection rules for patients and staff

1. Prepare for routine imaging and non imaging procedures
   a. Check study is appropriate to clinical history provided and the study has been justified under local procedures
   b. Relay sufficient and accurate information to other departments to ensure the patient is correctly prepared and available
   c. Check that all equipment, materials and consumables relevant to the test are available and correctly sited for use
   d. Confirm arrangements for the availability of the correct type and dosage of radioactive or non radioactive medicinal products
   e. Carry out routine quality assurance to check and confirm that the imaging system and output mechanisms are fully operational and are within specified parameters
      i. Prepare a suitable source for QC of the gamma camera
      ii. Obtain uniformity images/data using standard parameters and be aware of action thresholds
      iii. Check physical and mechanical condition of camera and collimators daily and report faults
      iv. Perform other gamma camera Q.C. procedures such as: linearity, spatial resolution, sensitivity
      v. Fit suitable collimator for radionuclide energy level, resolution and sensitivity that is required for the procedure to be performed
   f. Confirm scheduling of the procedure and amend preparation schedule as appropriate
   g. Prepare radiopharmaceutical for administration to patient
      i. Check identity and calculate activity and volume of radiopharmaceutical before administration
      ii. Perform QC on the ionisation chamber in accordance with local protocols
      iii. Prepare equipment for drawing up the patient dose
      iv. Aseptically dispense the radiopharmaceutical into a syringe taking into account radiation protection measures
      v. Measure patient dose in ionisation chamber
2. Review patient status and suitability for routine diagnostic procedures with patient present
   a. Confirm authorisation has been obtained before the procedure is commenced
   b. Check patient identity and confirm consent according to local procedures
   c. Confirm the relevant patient preparation has been completed including withdrawal or taking medication, dietary or other restrictions
   d. Identify specific contraindications or possible difficulties to the procedure and seek appropriate advice
   e. Adapt procedures for patients with special needs
   f. Confirm that other monitoring or other pre- investigation tests have been completed and results are available
   g. Monitor weight and height and make adjustment to administration dosage of radioactive &/or non-radioactive medical products as appropriate
   h. Assess radiation risks and advise patient and carers on any action to be taken upon leaving the immediate site

   i. Assess other risks including manual handling, infection control and take relevant action
3. Acquire and record data during a limited range of routine diagnostic imaging procedures
   a. Confirm patient identity, procedure, radioactive &/or non-radioactive products to be administered and time and date of imaging
   b. Give appropriate instructions to the patient to allow them to co-operate fully with the procedure avoiding unnecessary use of technical language, using interpreters if required
   c. Confirm administration of the correct medicinal product including dose activity, time and frequency both prior or during imaging
   d. Enter accurate patient information for correct data acquisition
   e. Select the correct settings/protocol for the procedure
   f. Select the appropriate technique to give the required information i.e. Dynamic, static, wholebody acquisition
   g. Capture data at required intervals and in the required format for analysis
   h. Use supporting or immobilising equipment
   i. Safely position monitoring and other equipment that may be connected to the patient
   j. Position anatomical markers to meet clinical need taking into account factors which may affect positioning, quality of image
   k. Observe the patient during the acquisition of data to detect movement and possible impact on data quality, taking remedial action as necessary
   l. Communicate with the patient to confirm the presence or cause of apparent or indicated pathology or abnormality. Performing extra views as necessary
   m. Observe and/or assist with the acquisition of a wide range of diagnostic imaging procedures
4. Perform a limited range of routine diagnostic non-imaging procedures
   a. Prepare precise patient standards and patient radionuclide activities.
      i. Assemble lab equipment to contain spillage
      ii. Use equipment to pipette with precision to produce reproducible results
   b. Perform or confirm routine QC procedures on the monitoring or measuring equipment
      i. Use standard sources to check sensitivity at specified energies and understand the need to report deviations
      ii. Check background levels of radiation
   c. Obtain specified pre-test samples &/or other patient information
   d. Confirm precise administration of correct medicinal product, including dosage, activity, time and frequency, prior or during procedures
   e. Confirm or administer any pre-investigation patient preparation.
   f. Confirm nuclear medicine procedure scheduling and alter if necessary.
   g. Obtain and pre-process routine and additional samples in correct volume and frequency required for specified procedure
   h. Maintain radiation protection and infection control measures throughout the procedure, including correct use of PPE
   i. Select the correct monitoring or measuring equipment to be used for the diagnostic procedure.
      i. Prepare samples for counting in scintillation counter
      ii. Select correct energy and window widths
      iii. Calculate cross channel correction if required
   j. Calculate and quality assure the results
   k. Complete all records accurately, legibly and store in correct location for next action
   l. Record any deviation or non-standard procedure.
   m. At this level perform Schilling tests and C14 breath tests, observe and participate in RCV/PV, GFR determination and white cell labelling

5. Manage radioactive patients who have undergone routine diagnostic investigations
   a. Continuously assess risks associated with management of radioactive patient
   b. Confirm patients understanding of procedure, requirements for compliance and possible side effects
   c. Provide the patient with written instructions prior to, immediately before commencement, during or after procedure as necessary

   d. Ensure safety of self, patient and others in controlled environments through consistent application of radiation protection and infection control measures
   e. Respond clearly and with the correct information to questions from patients, carers and staff
   f. Inform others who will have contact with the patient of requirements for compliance with radiation protection controls
   g. Confirm retained activity of high dose patients is below guidance limits before discharge or release from controlled areas
   h. Seek assistance and advice in the event of emergency, adverse incident or significant change in patient condition
6. Analyse results of routine nuclear medicine procedures
   a. Confirm correct data selected
   b. Transfer acquired data to analysis system if required
   c. Use validated software correctly for analysis
   d. Process the data using suitable operations to produce a result that may be interpreted clinically.
   e. Identify artefacts in the data caused by any aspect of the acquisition or processing
   f. Identify abnormalities or areas of interest
   g. Modify technique to suit individual patient or investigation needs.
   h. Validate accuracy of results using appropriate quality control.
   i. Produce a final display of correctly labelled results, including a hardcopy where required
   j. Indicate predictive nature of data by including normal ranges to assist with interpretation
   k. Record any variation in the data processing performed.
   l. Record any other unusual event noticed.
   m. Transfer results into database or other record for reporting
7. Prepare unsealed radiopharmaceuticals for nuclear medicine diagnostic investigations
   a. Maintain sterility in the Radiopharmacy and utilise aseptic technique
   b. Clean areas of the Radiopharmacy in accordance with local protocols
   c. Wear clothing appropriate to the area where working e.g. full suit in aseptic area
   d. Check environment integrity (room and cabinet pressures) and be aware of action levels
   e. Perform daily pre use check of the ionisation chamber
   f. Prepare for production in the clean area according to local protocols
   g. Elute 99m Technetium generator according to written protocol, perform 90 Molybdenum breakthrough check, measure the activity of the eluate
   h. Reconstitute a commercial kit in accordance with written protocol and manufacturers instructions
   i. Measure activity of reconstituted kit
8. Radiation protection in the nuclear medicine department
   a. Be aware of radiation safety procedure using gloves, shielding, distance and time to reduce exposure
   b. Follow procedures for storage and disposal of radioactive materials
   c. Carry out and document personal and environmental monitoring for radioactive contamination in accordance with local protocol
   d. Be aware of when to call for help
9. Understand the principles of and observe the administration of radionuclide therapy

Clinical Practice Placement Modules, Years 3 & 4. Nuclear Medicine Technology

In years 3 and 4 the student should build on the basic competencies attained in years 1 and 2 and extend them to the full range of imaging and non-imaging investigations. In addition the student should complete the following:

1. Schedule nuclear medicine procedures
    a. Where patient or other information is insufficient, liaise with clinician and other relevant personnel to obtain adequate information for referral to proceed.
    b. Identify patient specific information that has implications for staffing, protocols and other resources
    c. Confirm receipt of an authorised nuclear medicine referral in accordance with locally accepted criteria.
    d. Identify practitioner and ensure appropriate ARSAC certification according to local procedures
    e. Schedule appointments appropriately including arrangements for supply of radiopharmaceuticals
    f. Identify that necessary pre-investigation tests will be completed and results available
    g. Identify the availability of sufficient, suitably trained personnel and equipment.

2. Prepare for routine therapy procedures in conjunction with qualified staff
    a. Confirm therapy procedure is relevant to clinical history.
    b. Verify prescription and other clerical procedures for the administration of therapy meets locally accepted criteria
    c. Select appropriate radiopharmaceutical formulation based on patient need and therapeutic procedure
    d. Confirm local radioactive waste disposal limits allow performance of the therapeutic procedure
    e. Confirm safety measures are in place and facility complies with radiation protection standards
    f. Identify the availability of sufficient, suitably trained personnel and equipment to undertake the procedure and to care for the patient following therapy.
    g. Confirm scheduling of the procedure and amend preparation schedule as appropriate.
3. Obtain biological samples for use in diagnostic or therapeutic nuclear medicine procedures
    a. Check and confirm patients identity and consent for collection procedure
    b. Confirm nuclear medicine procedure scheduling and arrange sample collection taking accordingly
    c. For venous blood samples select suitable site matched to type and purpose of blood collection and to patient's clinical needs.
    d. Select and use correct sample collection system.
    e. Select and use correct personal protective or other equipment matched to type and purpose of sample collection, patient's clinical need and any biohazard that may be present.
    f. Obtain the correct volume of samples in suitable containers at correct time and label sample with appropriate information.
    g. Confirm patient's understanding and compliance with next stage
    h. Remove and dispose of clinical and non-clinical waste safely and immediately on completion of procedure
    i. If appropriate, protect the sample site from infection, ensure haemostasis and inform patient of any action to be taken
    j. Confirm patients current status and condition is suitable for next stage
    k. Record sample details and any other information relevant to successful outcome of the procedure.
    l. Shield sample effectively where appropriate
    m. Report incidents to relevant authorities

4. Radiopharmaceutical preparation
    a. Complete operator broth tests
    b. Perform a production run of radiopharmaceutical kits for diagnostic tests under supervision
    c. Assist with blood labelling
    d. Perform QC of the environment including settle and contact plates and download fridge data loggers
    e. Perform QC of the radiopharmaceutical using chromatography techniques
    f. Pack and transport radiopharmaceuticals according to regulations

Clinical Practice Placement Modules Years 1 and 2. Radiation Physics Technology

1. For all competences the student must be able to:
    a. Report in correct format, and at required level of detail for target audience, with recommendations for methodology for optimisation where appropriate
    b. Produce and issue report within specified timescale
2. Identify relevant safety features in a diagnostic x-ray room
3. Calibrate an x-ray survey meter for a particular radiation energy
4. Understand and comply with the local rules for work with ionising radiation within the x-ray department
5. Use optical sensitometry to calculate film characteristics
6. Collect, monitor and record radioactive waste
    a. Measure waste, including air sampling where appropriate, to demonstrate compliance with limitations on waste quantities
    b. Where direct measurement is not possible, use alternative accepted methodologies for estimating active content of wastes
    c. Ensure waste is in correct and suitable container for transfer
    d. Ensure accuracy of labelling for type, content and measurement of waste for transfer
    e. Utilise correct protective clothing and equipment when handling radioactive waste
    f. Collect waste material from departments, re-confirm suitability of containers and labelling for transfer
    g. Transfer to the appropriate waste store avoiding all risks of contamination, loss or related harm
    h. Store waste in correct location with labelling clearly visible
    i. Accurately record the content of each separate receptacle in the store
    j. Store records in correct location for access by authorised users
    k. Ensure security of waste storage facility
7. Provide a personnel monitoring service for staff working in radiation areas
    a. Process dosemeters and assess doses received using approved methods of dose calculation
    b. Report results of dose assessment, detailing non-compliant or high-risk issues.
    c. Create and maintain records of staff doses
8. Assess, audit and interpret patient radiation dose
    a. Develop forms and guidance for recording of relevant data to staff involved in the measurement process for simple audits
    b. Obtain results of measurements of patient doses
9. Measure and record levels and characteristics of radiation
    a. Select appropriate monitor or dosemeter for the type(s) of radiation to be measured
    b. Ensure selected apparatus is in working order and within calibration.
    c. Perform the full range of measurement activities specified.
    d. Record the results of measurements accurately and in correct format.
    e. Make results available to appropriate person within specified timescales
10. Quality assure x-ray imaging equipment on a range of basic X-ray equipment, and obtain supervised experience on more complex X-ray equipment (AEC, tomography etc.)
    a. Select routine tests to perform.
    b. Perform tests at recommended intervals, on the equipment to ascertain whether baselines established during the commissioning tests are being maintained.
    c. Analyse results and compare against expected performance, standards and guidance.
    d. Identify faults/poor performance.
    e. Recommend actions.
    f. Liase with other professionals who undertake quality control and make use of test data

Clinical Practice Placement Modules Years 3 and 4 Radiation Physics Technology

1. For all competences students must be able to:
    a. Report in correct format, and at required level of detail for target audience, with recommendations for methodology for optimisation where appropriate
    b. Produce and issue report within specified timescale
2. Perform critical examinations on protection equipment such as lead aprons and gloves
3. Carry out a radiation safety survey of a new x-ray facility to include tube leakage, effectiveness of room structure
4. Calibrate a batch of thermoluminescent dosemeters
5. Calibrate the response of x-ray film for various energies
6. Measure transmission of x-rays through aluminium under broad and narrow beam conditions
7. Estimate the total filtration of an x-ray tube assembly
8. Use fluoroscopy test objects to assess image quality
9. Accept and commission a range of x-ray imaging equipment
    a. Select appropriate acceptance and commissioning tests.
    b. Perform appropriate acceptance and commissioning tests on equipment according to recommended standards and guidelines.
    c. Analyse results and compare against expected performance, standards and guidance.
    d. Establish baseline performance.
    e. Correctly Identify faults/poor performance..
10. Quality assure a full range of x-ray imaging equipment
    a. Select routine tests to perform.
    b. Perform tests at recommended intervals, on the equipment to ascertain whether baselines established during the commissioning tests are being maintained.
    c. Analyse results and compare against expected performance, standards and guidance.
    d. Identify faults/poor performance.
11. Measure and report on image quality on basic fluoroscopic and more complex X-ray equipment (AEC, tomography etc)
    a. Select appropriate equipment and measurement technique for assessing image quality.
    b. Evaluate clinical image quality using published guidelines.
    c. Evaluate image quality using appropriate test objects.
    d. Compare results with accepted standards
12. Optimise practices involving radiation for a range of basic practices
    a. Obtain details of the exposed groups of individuals for whom consideration of optimisation is appropriate
    b. Analyse data relating to personal doses measured for each group
    c. Measure output and environmental doses and dose rates
    d. Calculate typical doses to individuals within each group and, where appropriate, collective doses to the group population based on output or environmental measurements of dose and dose rate
    e. Compare doses from potential options with doses from existing procedures
13. Quality assure equipment and radiation sources
    a. Schedule QA testing at the appropriate frequency and at the convenience of local users
    b. Obtain and Interpret results of tests in a meaningful and relevant way for the users
14. Audit areas where radiation is used
    a. Check records for usage, monitoring, contamination, decontamination, stock, disposals, QA testing, accidents and incidents are complete, current and comply with legislative requirements
    b. Confirm that control features and warning signs are in place
    c. Confirm that all relevant staff training has been completed
15. Investigate and report on legislative aspects of use of radiation throughout the organisation

   a. Identify areas within the organisation where radiation is used
   b. Obtain information from users on the type and extent of radiation used and how it is used
16. Co-ordinate storage, disposal and transfer of radioactive substances
   a. Consult with users to identify the types, quantities and physical form of radioactive materials being used by the organisation
   b. Obtain measurements, including air sampling where appropriate, to demonstrate compliance with limitations on waste quantities
   c. Maintain mechanisms for recording and monitoring of relevant details of waste materials
   d. Arrange for the collection of waste material from departments and transfer to the store
   e. Ensure accurate records are made of the content of each separate receptacle in the store
   f. Ensure that materials are removed in a timely fashion and that accumulation limits for the site are not breached
17. Audit and interpret environmental radiation monitoring results
   a. Collate results from all sources of environmental monitoring
   b. Analyse and summarise data in a manner which is appropriate for the purpose of extracting significant information
18. Audit and interpret staff dosimetry and workplace monitoring results
   a. Collate results from multiple sources on radiation doses
   b. Analyse and summarise data in a manner which is appropriate for the purpose of extracting significant information
19. Provide a personnel monitoring service for staff working in radiation areas
   a. Calibrate dosemeters used to give an accurate and traceable measure of dose received
   b. Contribute summary statistics of dose for a range of occupational categories to employers and national surveys
20. Assess radiation doses to members of the public
   a. Obtain information of the occupancy of areas where exposure is likely to take place
   b. Assess dose via measurement of individual or environmental exposure
   c. Report doses to managers and supervisors with responsibility for the use of radiation in that environment where the assessment took place
   d. Make measurement of dose and dose rates in the environment where public exposure may occur
21. Assess, audit and interpret patient radiation dose
   a. Install and calibrate the dosemeter to be used, or issue calibrated dosemeters
   b. Provide forms and guidance for recording of relevant data to staff involved in the measurement process
   c. Obtain results of measurements of patient doses
   d. Determine the typical dose and range of doses for each type of medical exposure
22. Measure and record levels and characteristics of radiation
   a. Select appropriate monitor or dosemeter for the type(s) of radiation to be measured
   b. Ensure selected apparatus is in working order and within calibration.
   c. Perform the full range of measurement activities specified.

Clinical Practice Placement Modules Years 1 and 2. Radiotherapy Physics Technology

1. Prepare sealed sources for use in brachytherapy
    a. follow local protocols for brachytherapy source preparation
    b. ensure relevant safety and emergency procedures are adhered to
    c. manage waste in compliance with Local Rules
    d. monitor preparation area for contamination
    e. locate and isolate source(s) of possible contamination
    f. handle radioactive sources with use of correct shielding and handling equipment
    g. check preparation is accurate
    h. verify source activity
    i. deliver prepared source in manner suitable for clinical use
    j. carry out leak testing of sources
2. Select and Customise patient related devices to assist with radiotherapy
    a. Customise patient related devices for immobilisation, positioning or shielding to meet the needs of the patient
    b. Produce patient related devices which are fit for purpose and appropriately labelled
    c. Provide the patient with sufficient information to ensure they understand the procedure involved
    d. Reassure and support the patient to enable their full co-operation
3. Take impression of patient for the production of a radiotherapy positioning device
    a. Prepare the patient for the technique and select the materials needed
    b. Ensure the patients' airway, involved fistulas and other areas of compromised tissue are protected
    c. Take an impression of the relevant area from the patient defect, avoiding harm or discomfort to the patient
    d. Decontaminate impression removing all blood, patient tissues and other body fluids
    e. Convert the impression to an analogue, using approved technique and materials
4. Produce patient specific radiotherapy positioning device
    a. Fabricate a positioning device using appropriate materials and components
    b. Trial fit the device on the patient and check for comfort, function and aesthetics
5. Quality control radiotherapy systems
    a. Apply agreed quality control measures and methods
    b. Check equipment is operating within agreed tolerances
    c. Use an auditable recording and document system
    d. Handover management and on-going evaluation to relevant, suitable trained personnel
    e. Take or initiate appropriate corrective action in respect of non-compliance
6. Perform treatment dose calculations for external beam radiotherapy for a simple plan
    a. Collate the relevant patient data and patient treatment related data and check for validity, consistency and completeness
    b. Check the relevance and validity of the treatment prescription against agreed departmental protocols
    c. Prepare the relevant patient data and patient treatment related data in a form appropriate for calculation.
    d. Check the integrity and appropriateness of the data charts / tables selected and apply the correct computer programmes / algorithms and corrections, according to departmental protocols, in order to calculate the treatment monitor units / time.
    e. Record all calculations, calculation results and treatment instructions according to departmental protocols to provide sufficient detail for the method and results to be verified sufficiently to satisfy an independent check and for the results to be used for treatment.
    f. Check accuracy of your calculations before handover for independent checking
    g. Recognise situations where you need to seek advice / support from appropriate sources and respond appropriately, e.g. where the complexity required exceeds your personal level of competence or where there is reason for concern about the patient's suitability for the prescribed treatment.

Clinical Practice Placement Modules Years 3 and 4. Radiotherapy Physics Technology

1. Perform treatment dose calculations for external beam radiotherapy
   a) Collate the relevant patient data and patient treatment related data and check for validity, consistency and completeness
   b) Check the relevance and validity of the treatment prescription against agreed departmental protocols e.g. where elements of the treatment prescription, especially dose-related elements, appear to be outside normal values to achieve the intended purpose of radiotherapy.
   c) Prepare the relevant patient data and patient treatment related data in a form appropriate for calculation.
   d) Check the integrity and appropriateness of the data charts / tables selected and apply the correct computer programmes / algorithms and corrections, according to departmental protocols, in order to calculate the treatment monitor units / time.
   e) Record all calculations, calculation results and treatment instructions according to departmental protocols to provide sufficient detail for the method and results to be verified sufficiently to satisfy an independent check and for the results to be used for treatment.
   f) Enter all relevant calculation results and treatment instructions into the treatment machine record and verification system, where appropriate.
   g) Check accuracy of your calculations before handover for independent checking
   h) Recognise situations where you need to seek advice / support from appropriate sources and respond appropriately, e.g. where the complexity required exceeds your personal level of competence or where there is reason for concern about the patient's suitability for the prescribed treatment.
2. Input data to record and verify systems
   a) Enter all relevant calculation results and treatment instructions into the treatment unit record and verify system.
   b) Check the entered data for consistency against the treatment prescription and other hardcopy data sources and ensure that there are no omissions, limitations or inconsistencies that would compromise adequate treatment.
3. Outline anatomical structures to agreed protocols
   a) Collate the relevant patient data and patient treatment related data and check for validity, consistency and completeness
   b) Check the relevance and validity of the proposed treatment against agreed departmental protocols. Review deviations from the protocols
   c) According to agreed local protocols identify and outline relevant organs at risk and the prescribed anatomical components of the clinical target volume by appropriate use of relevant imaging information, adding margins to the defined volumes where appropriate.
   d) Transfer data to and/ or collate data within the treatment planning system.
   e) Recognise situations where you need to seek advice / support and respond appropriately
4. Produce treatment plan for standard individual patient external beam radiotherapy using a planning computer
   a. Collate the relevant patient data and patient treatment related data and check for validity, consistency and completeness
   b. Check the relevance and validity of the proposed treatment against agreed departmental protocols. Review deviations from the protocol and take appropriate action.
   c. Check that the outlining and the addition of margins have been carried out according to agreed departmental protocols
   d. Use appropriate planning software and algorithms to produce a treatment plan which meets all required criteria
   e. Work interactively with the relevant clinical oncologist to review and optimise the treatment plan and to obtain acceptance and approval of the final plan.
   f. Critically review the treatment plan before handover for independent checking.
   g. Record all calculations, calculation results and treatment instructions according to departmental protocols

h. Enter all relevant calculation results and treatment instructions into the treatment machine record and verification system, where appropriate
i. Provide sufficient detail for the methodology and data to be verified sufficiently to satisfy an independent check and for the data to be used for treatment and treatment verification.

5. Produce treatment plan for individual brachytherapy patient treatment
   a. Provide a treatment plan and data relevant to the type, grade and stage of tumour
   b. Produce plans only for treatments at a level of complexity within your personal expertise
   c. Seek advice and support where level of complexity required exceeds your personal level of competence
   d. Identify anatomical points of interest for dose determinations
   e. Provide a treatment plan and data to achieve the intended purpose of radiotherapy
   f. Produce a treatment plan which is deliverable in both geometric and practical terms
   g. Check accuracy of your calculations
   h. Check validity, currency and authenticity of your data tables
   i. Check integrity and validity of patient related data including images
   j. Apply the correct algorithms, and corrections
   k. Satisfy relevant independent checks
   l. Carry out appropriate tests of the geometric accuracy of computer reconstructions of implants
   m. Produce a treatment plan and data and carry out associated calculations and check procedures within an agreed framework of safe working practices
   n. Provide sufficient detail to enable verification and application of the treatment plan
   o. Obtain acceptance and approval of the plan from the relevant clinician
   p. Enter all relevant calculation results and treatment instructions into the treatment machine record and verification system, where appropriate
6. Select and Customise patient related devices to assist with radiotherapy
   a. Select devices which are appropriate to treatment technique and individual patient needs
   b. Customise patient related devices for immobilisation, positioning or shielding to meet the needs of the patient
   c. Produce patient related devices which are fit for purpose and appropriately labelled
   d. Provide the patient with sufficient information to ensure they understand the procedure involved
   e. Reassure and support the patient to enable their full co-operation
7. Take impression of patient for the production of a radiotherapy positioning device
   a. Prepare the patient for the technique and select the materials needed
   b. Ensure the patients' airway, involved fistulas and other areas of compromised tissue are protected
   c. Decontaminate impression removing all blood, patient tissues and other body fluids
   d. Convert the impression to an analogue, using approved technique and materials
8. Produce patient specific radiotherapy positioning device
   a. Fabricate a positioning device using appropriate materials and components
   b. Trial fit the device on the patient and check for comfort, function and aesthetics
   c. Modify the device as required to ensure it is fit for purpose
   d. Re-assess patient and treatment technique needs and modify or realign device when necessary
   e. Check patient acceptance of the device and is comfortable with it
9. Specify and design treatment machine accessories and modifications to assist with radiotherapy
   a. Design treatment machine accessories that meet the needs of a particular treatment
   b. Use relevant computer planning tools and techniques to aid design and production where appropriate
   c. Access support from a multi-disciplinary team
   d. Assess safety issues relating to such devices
10. Perform dose measurements to support radiation treatment
   a. correctly read and interpret measurements from the range of equipment used
   b. select and use equipment and instruments within their capabilities and limitations
   c. identify and report damage or malfunction to the appropriate people
   d. record and report measurements taken for verification

   e. provide measurements in the required format and presentation
11. Conduct definitive calibration of radiation delivery and measurement devices
   a. Determine if Definitive Calibration is necessary
   b. Carry out Definitive Calibration following the current legal guidance
   c. Assess the readiness of the equipment for a Definitive Calibration to be carried out.
   d. Complete the necessary records and ensure that a second qualified person carries out the necessary checks
   e. Risk assess clinical use of equipment
12. Maintain radiotherapy equipment
   a. Check the characteristics of the radiation beam
   b. Check the optical and radiation alignment of the radiation beam
   c. Dismantle and assemble vacuum systems safely
   d. Carry out adjustments to beam parameters on linear accelerators
   e. Identify faults and take remedial action
   f. Identify issues that will affect the radiation beam and seek the appropriate level of physics advice
   g. Carry out appropriate handover procedures
   h. Use radiation measurement equipment including beam scanning equipment
   i. Verify the correct functioning of safety interlock systems

Clinical Practice Placement Modules, Years 1 & 2. Renal Technologist

1. Prepare the environment and install equipment for dialysis treatment
    a. Confirm that the location has suitable access for patients and equipment
    b. Confirm sufficient space for carrying out dialysis treatment
    c. Ensure appropriate storage space for consumables
    d. Ensure that a suitable power and water supplies and drainage are available
    e. Provide methods of water treatment to meet the specific needs of the installation
    f. Test the treated water to ensure that it complies with specified requirements
    g. Install dialysis equipment.
    h. Test equipment to ensure that it is fully operational.

2. Support people providing dialysis treatments
    a. Be available to provide support at agreed times and locations
    b. Identify operator reported faults, diagnose cause and take appropriate corrective action
    c. Recognise issues which are outside of your own level of competence and refer them to an appropriate professional

3. Provide quality control for water for dialysis
    a. Obtain suitable samples for testing using appropriate sampling techniques
    b. Store the samples in appropriate conditions
    c. Select the appropriate test procedure for each sample
    d. Analyse samples using in-house tests
    e. Submit samples to an appropriate laboratory
    f. Record results
    g. Monitor trends in water quality

4. Provide quality assurance for dialysis-related equipment
    a. Verify calibration of dialysis equipment
    b. Calibrate dialysis equipment
    c. Configure dialysis equipment settings using appropriate methods and procedures
    d. Obtain samples of dialysis fluid for chemical and microbiological testing using appropriate sampling techniques
    e. Analyse dialysis samples using in-house tests.
    f. Submit dialysis fluid samples to an appropriate laboratory
    g. Inspect external surfaces of equipment for contamination with blood or other body fluids
    h. Clean and disinfect contaminated surfaces using appropriate procedures
    i. Decontaminate equipment that has been used to treat patients infected with blood-borne viruses
    j. Disinfect dialysis equipment after interventions that breach the internal fluid pathways

5. Maintain a limited range of dialysis equipment for clinical use
    a. Make informed use of the detailed technical information provided by the manufacturers' service manuals
    b. Use appropriate test equipment and service tools
    c. Confirm test equipment is correctly calibrated for maintenance and repair activities
    d. Reference the correct protocol for type and range of equipment
    e. Complete planned preventive maintenance to specified schedule
    f. Diagnose faults and determine appropriate action
    g. Repair equipment
    h. Complete all records accurately and store in correct location for future use
    i. Seek advice or support when required maintenance activity falls outside own level of expertise

j. Assess decontamination status and requirements of the equipment to be maintained
k. Carry out suitable disinfect ion/cleaning procedures prior to maintenance

Clinical Practice Placement Modules, Years 3 & 4. Renal Technologist

1. Prepare the environment and install equipment for dialysis treatment

    a. Confirm that the location has suitable access for patients and equipment
    b. Confirm sufficient space for carrying out dialysis treatment
    c. Ensure appropriate storage space for consumables
    d. Ensure that a suitable power and water supplies and drainage are available
    e. Provide methods of water treatment to meet the specific needs of the installation
    f. Test the treated water to ensure that it complies with specified requirements
    g. Liaise with contractors, external agencies and suppliers.
    h. Liaise with local NHS Facilities Dept.
    i. Liaise with renal professionals as appropriate
    j. Install dialysis equipment.
    k. Test equipment to ensure that it is fully operational.
    l. Inform those involved in operating equipment of key requirements for use

2. Support people providing dialysis treatments

    a. Be available to provide support at agreed times and locations
    b. Identify operator reported faults, diagnose cause and take appropriate corrective action
    c. Recognise issues which are outside of your own level of competence and refer them to an appropriate professional

3. Provide quality control for water for dialysis

    a. Obtain suitable samples for testing using appropriate sampling techniques
    b. Store the samples in appropriate conditions
    c. Select the appropriate test procedure for each sample
    d. Analyse samples using in-house tests
    e. Submit samples to an appropriate laboratory
    f. Record results
    g. Interpret results
    h. Assess factors that may have influenced the results
    i. Initiate corrective actions with relevant degree of urgency to maintain quality standards
    j. Monitor trends in water quality

4. Provide quality assurance for dialysis-related equipment

    a. Verify calibration of dialysis equipment
    b. Calibrate dialysis equipment
    c. Configure dialysis equipment settings using appropriate methods and procedures
    d. Obtain samples of dialysis fluid for chemical and microbiological testing using appropriate sampling techniques
    e. Analyse dialysis samples using in-house tests.
    f. Submit dialysis fluid samples to an appropriate laboratory
    g. Interpret results and initiate corrective actions with relevant degree of urgency
    h. Inspect external surfaces of equipment for contamination with blood or other body fluids
    i. Clean and disinfect contaminated surfaces using appropriate procedures
    j. Decontaminate equipment that has been used to treat patients infected with blood-borne viruses
    k. Disinfect dialysis equipment after interventions that breach the internal fluid pathways

5. Maintain the full range of dialysis equipment for clinical use

    a. Make informed use of the detailed technical information provided by the manufacturers' service manuals
    b. Use appropriate test equipment and service tools
    c. Confirm test equipment is correctly calibrated for maintenance and repair activities
    d. Reference the correct protocol for type and range of equipment
    e. Complete planned preventive maintenance to specified schedule
    f. Diagnose faults and determine appropriate action
    g. Repair equipment
    h. Complete all records accurately and store in correct location for future use
    i. Inform users of the progress of repairs and advise on contingency arrangements
    j. Inform users of reasons for fault, action taken and how to avoid re-occurrence
    k. Seek advice or support when required maintenance activity falls outside own level of expertise
    l. Assess decontamination status and requirements of the equipment to be maintained
    m. Carry out suitable disinfect ion/cleaning procedures prior to maintenance