Appendix 2

Underpinning scientific knowledge

Core training (to be completed by ST4)

1. Cancer Biology and Radiobiology

The aims of this module are to allow the trainee to:

- understand the molecular basis of abnormalities which give rise to dysplasia, invasive cancer and metastases and
- understand the therapeutic effects and toxicity of ionising radiation at the level of cells, organs and organisms

The knowledge defined in this section will be assessed in the Cancer Biology and Radiobiology module of the First FRCR examination.

1.1 Principles of tumour biology

Discusses the general principles of tumour biology		
Knowledge	**Assessment Methods**	**GMP**
Defines and can distinguish between different types of growth disorder, e.g. dysplasia and carcinoma in situ	First FRCR (Cancer Biology and Radiobiology)	1
Describes the cell cycle, basic cell kinetics and control mechanisms	First FRCR (Cancer Biology and Radiobiology)	1
Describes the mechanisms of spread, local invasion/migration, metastasis	First FRCR (Cancer Biology and Radiobiology)	1
Describes the effects of tumours: local (e.g. pressure), distant (metastatic and non-metastatic)	First FRCR (Cancer Biology and Radiobiology)	1
Discusses the importance of tumour vasculature and angiogenesis	First FRCR (Cancer Biology and Radiobiology)	1
Describes mechanisms of DNA damage and repair: Single strand DNA breaks: • Base excision repair (BER) • Nucleotide excision repair (NER) • Mismatch repair (MMR) Double strand DNA breaks: • Non-homologous end joining (NHEJ) • Homologous recombination	First FRCR (Cancer Biology and Radiobiology)	1
Described the potential role of cancer stem cells	First FRCR (Cancer Biology and Radiobiology)	1
Describes mechanisms of cell death, e.g. apoptosis, autophagy	First FRCR (Cancer Biology and Radiobiology)	1
Describes the molecular targets for anti cancer therapy	Cancer Biology and Radiobiology	1

1.2 Genetics of normal and malignant cells

Discusses the genetics of normal and malignant cells		
Knowledge	**Assessment Methods**	**GMP**
Describes normal chromosomal structure and function, normal gene transcription and its control	First FRCR (Cancer Biology and Radiobiology)	1
Describes polymorphisms and microsatellites	First FRCR (Cancer Biology and Radiobiology)	1
Describes chromatin structure and function	First FRCR (Cancer Biology and Radiobiology)	1
Describes the importance of methylation	First FRCR (Cancer Biology and Radiobiology)	1
Discusses chromosomal and genetic changes in malignancy, point mutations, translocations, deletions, gene amplification and over-expression	First FRCR (Cancer Biology and Radiobiology)	1
Discusses oncogenes, proto-oncogenes, tumour suppressor genes and their mode of action, describing well established examples in each class	First FRCR (Cancer Biology and Radiobiology)	1

1.3 Normal and aberrant mechanisms of cell growth control

Discusses the normal and aberrant mechanisms of cell growth control		
Knowledge	**Assessment Methods**	**GMP**
Discusses the control of normal cell growth and behaviour	First FRCR (Cancer Biology and Radiobiology)	1
Contrasts autocrine, paracrine and endocrine growth factors	First FRCR (Cancer Biology and Radiobiology)	1
Discusses altered expression, function and control of these mechanisms in malignancy	First FRCR (Cancer Biology and Radiobiology)	1
Describes signal transduction	First FRCR (Cancer Biology and Radiobiology)	1
Describes gene promoters and their activity in normal and malignant cells	First FRCR (Cancer Biology and Radiobiology)	1

1.4 General principles of radiobiology

Discusses the general principles of radiobiology		
Knowledge	**Assessment Methods**	**GMP**
Describes cellular systems (hierarchical, flexible) and their response to radiation	First FRCR (Cancer Biology and Radiobiology)	1
Contrasts parallel and serial systems	First FRCR (Cancer Biology and Radiobiology)	1
Outlines the principles of cell survival curves, regrowth curves, clonogenic assay).	First FRCR (Cancer Biology and Radiobiology)	1
Describes the relevance of Linear Energy Transfer (LET) to cellular damage	First FRCR (Cancer Biology and Radiobiology)	1
Describes radiation damage at the cellular level (including outcome phenotypes, chromosome damage and cell radiosensitivity)	First FRCR (Cancer Biology and Radiobiology)	1
Describes the molecular biology of radiation damage and repair	First FRCR (Cancer Biology and Radiobiology)	1
Compares bystander with direct effects of radiation	First FRCR (Cancer Biology and Radiobiology)	1
Describes interactions between systemic anti cancer therapies and radiotherapy	First FRCR (Cancer Biology and Radiobiology)	1

1.5 Normal tissue radiobiology

Discusses normal tissue radiobiology		
Knowledge	**Assessment Methods**	**GMP**
Describes normal tissue damage (early and late)	First FRCR (Cancer Biology and Radiobiology)	1
Discusses the concept of normal tissue tolerance	First FRCR (Cancer Biology and Radiobiology)	1
Discusses Equivalent Uniform Dose (EUD)	First FRCR (Cancer Biology and Radiobiology)	1
Discusses the genetic factors and comorbidities, including auto-immune factors, which influence tolerance	First FRCR (Cancer Biology and Radiobiology)	1
Describes the effects of radiation on different tissues and organs including unplanned whole body exposure	First FRCR (Cancer Biology and Radiobiology)	1
Discusses organ tolerance to retreatment with radiation	First FRCR (Cancer Biology and Radiobiology)	1,2

1.6 Radiotherapy fractionation

Discusses the principles underlying radiotherapy fractionation		
Knowledge	**Assessment Methods**	**GMP**
Discusses the concept of lethal, sublethal, potentially lethal damage	First FRCR (Cancer Biology and Radiobiology)	1
Discusses the concept of early and late repair	First FRCR (Cancer Biology and Radiobiology)	1
Describes the effect of cell cycle on radiation sensitivity	First FRCR (Cancer Biology and Radiobiology)	1
Discusses repopulation	First FRCR (Cancer Biology and Radiobiology)	1
Explains the role of the cell survival curve as a basis for fractionation	First FRCR (Cancer Biology and Radiobiology)	1
Describes the linear quadratic model	First FRCR (Cancer Biology and Radiobiology)	1
Defines terms describing cellular sensitivity (SF2, α, β, mean inactivation dose)	First FRCR (Cancer Biology and Radiobiology)	1
Discusses the α/β ratio and its relevance to tumours, acute and late responding tissues	First FRCR (Cancer Biology and Radiobiology)	1
Calculates Biological Effective Dose (BED)	First FRCR (Cancer Biology and Radiobiology)	1
Defines and uses EQD2	First FRCR (Cancer Biology and Radiobiology)	1
Discusses fractionation and its influence on tumour control with different α/β ratio	First FRCR (Cancer Biology and Radiobiology)	1
Defines hyperfractionation, accelerated fractionation and hypofractionation	First FRCR (Cancer Biology and Radiobiology)	1
Discusses the influence of gaps in radiotherapy and their management	First FRCR (Cancer Biology and Radiobiology)	1
Describes the influence of dose rate effects, including low, pulsed, medium and high dose rate	First FRCR (Cancer Biology and Radiobiology)	1
Defines relative biological effect (RBE) and discusses its relationship to LET	First FRCR (Cancer Biology and Radiobiology)	1
Explains the influence of oxygen on radiosensitivity, including oxygen enhancement ratio (OER)	First FRCR (Cancer Biology and Radiobiology)	1
Explains the role of reoxygenation	First FRCR (Cancer Biology and Radiobiology)	1
Explains the relationship between OER and LET	First FRCR (Cancer Biology and Radiobiology)	1

1.7 Causation of human cancers

Discusses the inherited and non-inherited causation of human cancers

Knowledge	Assessment Methods	GMP
Describes the following non-inherited factors and influences • environmental; • chemical; • lifestyle; • viral and non-viral infection; • inflammatory; • ionising and non-ionising radiation	First FRCR (Cancer biology and Radiobiology)	1
Discuss underlying genetic abnormality, its mechanism of action and associated cancers in: o Retinoblastoma o Wilm's tumour o Familial adenomatous polyposis coli o Hereditary non-polyposis colon cancer o Familial breast cancer o Li Fraumeni o Neurofibromatosis 1 o MEN 1 o MEN 2 o Xeroderma pigmentosum o Ataxia telangiectasia o Peutz-Jeghers syndrome o Von Hippel-Lindau o Cowden syndrome Recognises other inherited cancer syndromes: o Familial melanoma o Bloom's syndrome o Nijmegen break o Cockayne's syndrome	First FRCR (Cancer biology and Radiobiology)	1

1.8 Role of the immune system

Describes the role of the immune system

Knowledge	Assessment Methods	GMP
Outlines the basic principles of immunoediting, including elimination, equilibrium and escape	First FRCR (Cancer biology and Radiobiology)	1
Outlines the basic principles of tumour immunology: • Fundamentals of immune response - innate versus adaptive immunity. • Relevant cell types including T cells (CD4 and CD8), B cells, dendritic cells. • Antibodies. • Immune tolerance; self/non-self, danger hypothesis. • MHC class I and II. • Immunomodulation, including co-stimulation and negative regulation. • Tumour associated antigens. • Immune suppression by tumours; tumour infiltrating lymphocytes, regulatory T cells.	First FRCR (Cancer biology and Radiobiology)	1

2. Clinical Pharmacology

The aim of this module is for the trainee to gain the knowledge underpinning the safe, appropriate and effective use of drugs for systemic therapy and symptomatic treatment of cancer.

The knowledge defined in this section will be assessed in the Clinical Pharmacology module of the First FRCR examination.

The anti cancer drugs covered in this module are set out in the "List of Anti Cancer Drugs" published as Addendum A to this Appendix.

2.1 Mode of action of cytotoxic drugs

Describes the mode of action of cytotoxic drugs

Knowledge	Assessment Methods	GMP
Describes the mechanisms of action for each drug	First FRCR (Clinical pharmacology)	1
Discusses the mechanisms of drug resistance	First FRCR (Clinical pharmacology)	1
Describes strategies to optimise efficacy of cytotoxic therapy	First FRCR (Clinical pharmacology)	1

2.2 Toxicity of systemic therapies

Discusses the toxicity of systemic therapies

Knowledge	Assessment Methods	GMP
Describes the dose limiting and common toxicities	First FRCR (Clinical pharmacology)	1,2
Describes dose-related and idiosyncratic toxicity	First FRCR (Clinical pharmacology)	1,2
Defines the concepts of acute and long-term toxicity	First FRCR (Clinical pharmacology)	1
Discusses the mechanisms of toxicity	First FRCR (Clinical pharmacology)	1
Discusses chemical and other factors modifying drug toxicity	First FRCR (Clinical pharmacology)	1,2
Describes principles of managing cytotoxic extravasation	First FRCR (Clinical pharmacology)	1,2

2.3 Pharmacokinetics and pharmacodynamics

Discusses pharmacokinetics and pharmacodynamics		
Knowledge	**Assessment Methods**	**GMP**
Discusses the principles of pharmacokinetics and interprets pharmacokinetic data	First FRCR (Clinical pharmacology)	1
Explains the role of the route and timing of administration	First FRCR (Clinical pharmacology)	1
Discusses the importance of plasma concentration and its relationship to drug actions	First FRCR (Clinical pharmacology)	1
Defines Area Under Curve (AUC) and discusses its importance	First FRCR (Clinical pharmacology)	1
Discusses drug activation, metabolism and clearance	First FRCR (Clinical pharmacology)	1
Discusses the importance of protein and tissue binding	First FRCR (Clinical pharmacology)	1
Describes the importance of drug concentration at target site	First FRCR (Clinical pharmacology)	1

2.4 Clinical use of systemic therapies

Discusses the principles of clinical use of systemic therapies		
Knowledge	**Assessment Methods**	**GMP**
Describes dose response curves	First FRCR (Clinical pharmacology)	1
Explains the concept of dose intensity	First FRCR (Clinical pharmacology)	1
Discusses the effects of single agent and combination therapy	First FRCR (Clinical pharmacology)	1
Discusses the interactions of systemic therapy with other modalities of treatment	First FRCR (Clinical pharmacology)	1
Describes the principles of regional therapy	First FRCR (Clinical pharmacology)	1
Describes safe practice in intrathecal treatment	First FRCR (Clinical pharmacology)	1
Outlines the principles of high dose therapy	First FRCR (Clinical pharmacology)	1

2.5 Clinical pharmacology of supportive therapies

Discusses the clinical pharmacology of anti-emetics and steroids

Knowledge	Assessment Methods	GMP
Lists the classes of anti-emetics and discusses their use	First FRCR (Clinical pharmacology)	1
Discusses the use of steroids	First FRCR (Clinical pharmacology)	1
Discusses use of haemopoietic growth factors	First FRCR (Clinical pharmacology)	1

2.6 Clinical pharmacology of analgesics

Discusses the clinical pharmacology of analgesics

Knowledge	Assessment Methods	GMP
Outlines the clinical pharmacology of analgesics and co-analgesics	First FRCR (Clinical pharmacology)	1
Discusses the use of drug combinations for pain management	First FRCR (Clinical pharmacology)	1
Describes different formulations and their use	First FRCR (Clinical pharmacology)	1

2.7 Drug interactions in cancer treatment

Discusses drug interactions in cancer treatment

Knowledge	Assessment Methods	GMP
Discusses common or important interactions between drugs used in cancer therapy and other commonly used drugs	First FRCR (Clinical Pharmacology)	1,2

3. Medical Statistics

The aim of this module is for the trainee to gain the statistics knowledge necessary to:

- understand the design of trials
- read and use a trial protocol
- present and interpret data
- interpret results of clinical trials
- critically review and evaluate papers

The knowledge defined in this section will be assessed in the Medical Statistics module of the First FRCR examination.

3.1 Types of data

Recognises different types of data		
Knowledge	**Assessment Methods**	**GMP**
Presents and summarises individual variables	First FRCR (Medical Statistics)	1
Recognises categorical data (nominal, ordinal)	First FRCR (Medical Statistics)	1
Recognises discrete and continuous numerical data	First FRCR (Medical Statistics)	1
Recognises symmetric and skewed distribution	First FRCR (Medical Statistics)	1
Describes the normal distribution	First FRCR (Medical Statistics)	1
Interprets bar charts and histograms	First FRCR (Medical Statistics)	1
Defines and applies measures of central tendency and spread	First FRCR (Medical Statistics)	1

3.2 Sampling

Explains sampling		
Knowledge	**Assessment Methods**	**GMP**
Describes the concept of a source population	First FRCR (Medical Statistics)	1
Explains random sampling	First FRCR (Medical Statistics)	1
Explains estimation of population statistics	First FRCR (Medical Statistics)	1
Describes standard error of a sample mean and of a proportion, and their differences	First FRCR (Medical Statistics)	1
Defines and uses confidence intervals	First FRCR (Medical Statistics)	1
Explains reference ranges	First FRCR (Medical Statistics)	1

3.3 Statistical inference

Explains the principles of statistical inference		
Knowledge	**Assessment Methods**	**GMP**
Explains hypothesis testing and estimation	First FRCR (Medical Statistics)	1
Contrasts Type I and II errors	First FRCR (Medical Statistics)	1
Interprets p-values and confidence intervals	First FRCR (Medical Statistics)	1
Defines and identifies the difference between statistical and clinical significance	First FRCR (Medical Statistics)	1
Explains the concept of and correction for multiple testing (e.g. false discovery rate, Bonferroni correction)	First FRCR (Medical Statistics)	1

3.4 Tests used to compare two or more groups

Identifies the tests used to compare two or more groups		
Knowledge	**Assessment Methods**	**GMP**
Selects an appropriate test for comparing means, e.g. t-tests, paired-t, Mann-Whitney, Wilcoxon's signed ranks, ANOVA and Kruskal-Wallis	First FRCR (Medical Statistics)	1
Selects an appropriate test for comparing percentages, e.g. chi squared, Fisher's exact and McNemar's	First FRCR (Medical Statistics)	1

3.5 Association between variables

Interprets measures and tests of association between variables		
Knowledge	**Assessment Methods**	**GMP**
Interprets the meaning of correlation and regression analysis	First FRCR (Medical Statistics)	1
Interprets the meaning of scatter plots	First FRCR (Medical Statistics)	1

3.6 Screening tests

Describes the statistical basis of screening tests		
Knowledge	**Assessment Methods**	**GMP**
Calculates and interprets the meaning of sensitivity, specificity and positive and negative predictive values	First FRCR (Medical Statistics)	1,2

3.7 Survival analysis

Discusses survival analysis

Knowledge	Assessment Methods	GMP
Lists types of time-to-event data	First FRCR (Medical Statistics)	1
Interprets and describes the principles of Kaplan-Meier and actuarial survival curves	First FRCR (Medical Statistics)	1
Describes the possible methods of summarizing survival data	First FRCR (Medical Statistics)	1
Outlines methods used to compare groups: • logrank test for two or more groups, including ordered groups • Cox's proportional hazards regression model • hazard ratios and their interpretation	First FRCR (Medical Statistics)	1

3.8 Design and analysis of clinical trials

Discusses the design and analysis of clinical trials

Knowledge	Assessment Methods	GMP
Compares the design and role of phases I-IV of clinical trials	First FRCR (Medical Statistics)	1
Explains the need for randomization and the problems with non-randomised studies and historical controls	First FRCR (Medical Statistics)	1
Describes the methods of randomisation (simple, block, stratified minimisation)	First FRCR (Medical Statistics)	1
Explains the concepts of blinding/masking	First FRCR (Medical Statistics)	1
Describes the possible trial designs: parallel group, cross-over, factorial	First FRCR (Medical Statistics)	1
Describes the contents of a trial protocol	First FRCR (Medical Statistics)	1
Discusses the ethical basis for research of what constitutes informed consent and reporting adverse events	First FRCR (Medical Statistics)	1
Describes the possible measures of response including: • tumour regression • quality of life • toxicity • local and regional recurrence • distant metastases • death • cause specific death	First FRCR (Medical Statistics)	1
Outlines the principles of: • sample size calculation • Interim analyses • Intent-to-treat analysis	First FRCR (Medical Statistics)	1
Outlines the role and basic principles of meta-analysis	First FRCR (Medical Statistics)	1

3.9 Collection and use of epidemiological data

Outlines the collection and use of epidemiological data		
Knowledge	**Assessment Methods**	**GMP**
Contrasts the design and interpretation of cross-sectional case control and cohort studies	First FRCR (Medical Statistics)	1
Defines the principles of, calculates and interprets odds ratios and risk ratios	First FRCR (Medical Statistics)	1
Defines incidence, prevalence, mortality rates and standardised mortality rates	First FRCR (Medical Statistics)	1
Outlines the principles of cancer registration	First FRCR (Medical Statistics)	1

4. Physics

The knowledge defined in this section will be assessed in the Physics module of the First FRCR examination.

The aim of this module is to allow the trainee to gain the knowledge and understanding of physics that underpin current radiotherapy practice, including:

- the interaction of ionising radiation with matter;
- how a desired dose distribution is produced, calculated and quality assured;
- how the dose of unintended radiation can be minimised for patients and staff.

4.1 Physics relevant to radiotherapy

Discusses the basic physics relevant to radiotherapy		
Knowledge	**Assessment Methods**	**GMP**
Describes atomic structure, atomic and mass numbers	First FRCR (Physics)	1
Describes electron shells and energy levels	First FRCR (Physics)	1
Describes electromagnetic radiation and the electromagnetic spectrum	First FRCR (Physics)	1
Describes energy quantitisation	First FRCR (Physics)	1
Explains the relationship between wavelength, frequency and energy	First FRCR (Physics)	1
Describes an x- or gamma-ray beam (quality, energy, intensity, size)	First FRCR (Physics)	1
Explains the basic principles of production of x- or gamma-rays	First FRCR (Physics)	1
Contrasts continuous and discrete spectra	First FRCR (Physics)	1
Describes attenuation, absorption, scattering of x-rays	First FRCR (Physics)	1
Defines attenuation coefficients and half value layer	First FRCR (Physics)	1

4.2 Electromagnetic radiation and its interaction with matter

Discusses electromagnetic radiation and its interaction with matter		
Knowledge	**Assessment Methods**	**GMP**
Discusses the nature of the following effects and their dependence on the properties of the irradiated material (e.g. density, atomic number), their variation with energy and their relative importance in therapy and imaging: • Compton effect • Photoelectric effect • Pair production • Photonuclear interactions • Auger effect • Scattered radiation • Secondary electrons • Linear energy transfer	First FRCR (Physics)	1

4.3 Interaction of sub atomic particles with matter

Discusses the interaction of sub atomic particles with matter		
Knowledge	**Assessment Methods**	**GMP**
Discusses: • Ionisation and excitation due to charged particles • Electrons ▪ collision loss ▪ radiative loss ▪ stopping power due to each and total stopping power ▪ particle range ▪ Bragg peak • Bremsstrahlung • Neutrons: elastic and inelastic collisions • Protons, ionisation profile	First FRCR (Physics)	1

4.4 Radiation dosimetry

Discusses radiation dosimetry

Knowledge	Assessment Methods	GMP
Discusses: • Variation of absorbed dose in different tissues and materials • Concept of exposure and KERMA • the principles of the relationship between exposure, KERMA and absorbed dose • The physical principles underlying radiation dose measurement • Methods of measurement, including the advantages and disadvantages of the following: ▪ ionisation methods (ionisation chamber, Geiger counter, diodes) ▪ chemical methods, primarily films ▪ thermoluminescence (TLD) ▪ scintillation counters ▪ calorimetry • Calibration ▪ standards (local and national) ▪ Intercomparisons, corrections, constancy checks • Practical dose measurements ▪ derivation of isodose curves ▪ central axis depth dose profiles ▪ use of phantoms	First FRCR (Physics)	1,2

4.5 Physics of teletherapy beams

Discusses the physics of teletherapy beams (x-rays)		
Knowledge	**Assessment Methods**	**GMP**
Describes energy ranges of x-rays used in clinical practice	First FRCR (Physics)	1
Discusses the dose distribution for therapeutic x-rays noting the effects on the isodose curve (% depth dose and beam profile) of: • energy • FSD (Focus to Skin Distance) • Beam modifying devices such as wedges, tissue compensators • Build-up and skin sparing • Field size • Tissue compensators • Surface obliquity • Inhomogeneous media	First FRCR (Physics)	1
Uses output factors to calculate monitor units and undertakes simple monitor unit calculations	First FRCR (Physics)	1
Describes beam geometry • penumbra • field size definition	First FRCR (Physics)	1

4.6 Physics of electron beams

Discusses electron beam physics		
Knowledge	**Assessment Methods**	**GMP**
Describes the dose distribution of electron beams used in clinical practice noting the effect on the isodose curve (% depth dose and beam profiles) of: • energy • tissue factors affecting dose at depth (e.g. lung) • field size • build up and skin sparing • surface obliquity and inhomogeneities • shielding	First FRCR (Physics)	1

4.7 Radiotherapy treatment planning

Explains the principles of radiotherapy treatment planning		
Knowledge	**Assessment Methods**	**GMP**
Discusses the techniques available to optimise patient set-up	First FRCR (Physics)	1
Discusses the effects of patient and organ movement	First FRCR (Physics)	1
Describes the methods of tumour volume definition : clinical examination, radiograph, CT, MRI, ultrasound, functional imaging	First FRCR (Physics)	1
Explains the concept of planning volumes (ICRU 50, 62): • Gross Tumour Volume (GTV) • Clinical Target Volume (CTV) • Planning Target Volume (PTV) ▪ Internal Target Volume (ITV) ▪ Set-up Margin (SM) • Treated Volume • Irradiated Volume • Organs at risk (OAR) • Planning organ at Risk Volume (PRV)	First FRCR (Physics)	1
Explains the methods of planning volume localisation: • Clinical mark-up • CT, MRI or PET simulation • Ultrasound	First FRCR (Physics)	1
Compares fixed FSD versus isocentric planning	First FRCR (Physics)	1
Describes isodose distributions, their uses and critical assessment in each of the following situations: • single field • multifield (coplanar and non-coplanar) • arc and rotational therapy • weighting	First FRCR (Physics)	1
Outlines the principles of beam shaping including conformal therapy, IMRT and VMAT	First FRCR (Physics)	1
Outlines the principles of forward and inverse planning	First FRCR (Physics)	1
Discusses dose prescription including ICRU 50, 62, 83	First FRCR (Physics)	1
Outlines the principles of dose calculations in the presence of extensive shielding	First FRCR (Physics)	1
Explains the principles of field matching	First FRCR (Physics)	1
Describes the principles of plan evaluation and verification using isodose display, dose volume histograms (DVH, cumulative and frequency) and digitally reconstructed radiographs (DRR)	First FRCR (Physics)	1

4.8 Beam therapy equipment

Explains the principles of beam therapy equipment		
Knowledge	**Assessment Methods**	**GMP**
Outlines the principles of superficial and orthovoltage x-ray production	First FRCR (Physics)	1
Outlines the principles of the linear accelerator, including: • electron beam production • x-ray production, beam control and stability • output • IMRT and VMAT	First FRCR (Physics)	1
Describes the concept and definition of the isocentre	First FRCR (Physics)	1
Describes the techniques for defining the beam geometry: • collimators • applicators • multileaf collimators	First FRCR (Physics)	1
Explains the factors influencing penumbra	First FRCR (Physics)	1
Defines beam quality	First FRCR (Physics)	1
Describes the shielding techniques available and the materials used in their construction	First FRCR (Physics)	1
Explains the concepts of transmission, scatter and doses under shields	First FRCR (Physics)	1
Discusses the factors involved in accurately irradiating the target: • the treatment couch • positioning of the patient • lasers • light fields • monitoring radiation output	First FRCR (Physics)	1,2
Describes the functioning of multileaf collimators: • edge definition • leaf leakage • influence of leaf size	First FRCR (Physics)	1
Outlines the principles of stereotactic equipment	First FRCR (Physics)	1

4.9 Quality assurance in radiotherapy

Describes quality assurance in radiotherapy		
Knowledge	**Assessment Methods**	**GMP**
Defines quality assurance and quality control in radiotherapy	First FRCR (Physics)	1,2
Describes the processes that are undertaken to ensure that the prescription is correctly implemented: • The role of computer verification • Manual checking • Monitoring accuracy of treated volume: off line and on line IGRT • Monitoring accuracy of positioning (lasers, light-fields, tolerances) • In vivo dosimetry	First FRCR (Physics)	1,2
Outlines monitoring to assure accuracy of; • Radiation output: • Symmetry and • Field flatness • Beam energy • Field size	First FRCR (Physics)	1,2
Describes the rules for reporting near misses and errors including the legal requirements	First FRCR (Physics)	1,2

4.10 Radioactive sources in therapy

Describes the use of radioactive sources in therapy		
Knowledge	**Assessment Methods**	**GMP**
Describes the basic principles of radioactivity including: • types and characteristics of radiation and radioactive decay • isotopes • definitions and units of activity and half-life including physiological and biological half life • sealed and unsealed sources • specific forms of sealed and unsealed sources including ^{192}Ir, ^{131}I, ^{125}I, ^{89}Sr, ^{90}Sr, ^{60}Co, ^{223}Ra, ^{90}Y • inverse square law • specifications of source strength, air KERMA rate • dose distributions around sealed sources • hazards with sealed and unsealed sources • control and testing of sealed sources • methods of source handling • safety devices available • methods of measurement in air KERMA rate	First FRCR (Physics)	1,2
Compares and contrasts use of teletherapy and brachytherapy	First FRCR (Physics)	1,2
Explains the principles of afterloading	First FRCR (Physics)	1,2
Explains principles of brachytherapy treatment planning	First FRCR (Physics)	1

4.11 Radiation protection

Discusses the principles of radiation protection		
Knowledge	**Assessment Methods**	**GMP**
Explains radiation protection mechanisms, including time, distance, shielding	First FRCR (Physics)	1,2
Discusses quality factors and dose equivalent	First FRCR (Physics)	1,2
Discusses background radiation	First FRCR (Physics)	1,2
Describes the statutory framework for radiation protection	First FRCR (Physics)	1,2
Describes the classification of staff, designated areas	First FRCR (Physics)	1,2
Outlines the principles of : • IR(ME)R • ARSAC • Local rules • Controlled areas	First FRCR (Physics)	1,2
Explains the design of treatment rooms: • Primary/secondary barriers • Transmission through barriers • Mazes, doors and interlocks • Leakage and scattered radiation	First FRCR (Physics)	1,2
Lists the methods of monitoring of personnel e.g.: • TLD badge • direct reading dosemeter	First FRCR (Physics)	1,2