

Radiological Physics/ Medical Physics

FACULTY OF MEDICINE

Syllabus for Ph. D. Admission test 2024-25 *Onwards*Section B**BASIC RADIATION PHYSICS**

Atomic structure, atomic number, mass number, isotopes, radioisotopes, Radioactivity Specific activity, Laws of radioactivity, Laws of successive transformations, Natural radioactive series, Radioactive equilibrium. Alpha ray spectra - Beta ray spectra - Theory of beta decay - Gamma emission - Electron capture - Internal conversion - Nuclear isomerism - Artificial radioactivity - Nuclear cross sections - Elementary ideas of fission and reactors - Fusion. Radioactive dating. Accelerator mass spectrometry, Production of radioisotopes by neutron and charged particle bombardments, nuclear cross section. Radiation sources, Natural and artificial radioactive sources, Large scale production of isotopes @Reactor produced isotopes, Cyclotron produced isotopes, Fission products, industrial uses, Telecobalt and Brachy Cesium sources, Gold seeds, Tantalum wire, ^{125}I , ^{131}I Sources, Beta ray applicators, Thermal and fast neutron sources, Preparation of tracers and labelled compounds, Preparation of radio colloids.

INTERACTION OF RADIATION WITH MATTER

Interaction of charged particle with matter, Classical theory of inelastic collisions with atomic electrons, Energy loss per ion pair by primary and secondary ionization Dependence of collision energy losses on the physical and chemical state of the absorber Cerenkov radiation, Electron absorption process, Scattering Excitation and Ionization & Radiative collision, Bremsstrahlung, Range energy relation, Continuous slowing down approximation (CSDA), straight ahead approximation and detour factors, transmission and depth dependence methods for determination of particle penetration, empirical relations between range and energy, Back scattering. Passage of heavy charged particles through matter - Energy loss by collision - Range energy relation - Bragg curve - Specific ionization - Stopping Power - Bethe Bloch Formula. Interaction of neutrons with matter - scattering - capture - Neutron induced nuclear reactions.

BASIC X-RAY PHYSICS

Discovery, Production, Properties of X-rays, Characteristics and continuous spectra, Design of hot cathode X-ray tube, Basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes, Rotating anode tubes, Hooded anode tubes, Industrial X-ray tubes, X-ray tubes for crystallography, Rating of tubes, Safety devices in X-ray tubes, X-Ray proof and shockproof tubes, Insulation and cooling of X-ray tubes, Mobile and dental units, Faults in X-ray tubes, Limitations on loading. Physical principle of diagnostic radiology: Interactions of X-rays with human body, differential transmission of x-ray beam, spatial image formation, visualization of spatial image, limitations of projection imaging technique Viz. superimposition of overlying structures and scatter, application of contrast media and projections at different angles to overcome superimposition of overlying structures.

RADIATION QUANTITIES, UNITS AND DOSIMETRY

Particle flux and fluence, Energy flux and fluence, Cross Section, Linear and mass attenuation coefficients, Mass energy transfer and mass energy absorption coefficients, Stopping power, LET, Radiation chemical yield, W-value, Dosimetry, Energy imparted, Absorbed dose, Kerma, Exposure, Air kerma rate constant, Charged particle equilibrium (CPE), Relationship between Kerma, absorbed dose and exposure under CPE, Dose equivalent, Effective dose, Collective effective dose, Annual limit of intake (ALI), Derived Air Concentration (DAC), Personnel dose equivalent Committed dose. Free Air Ion Chamber (F-AIC), Design of parallel plate F-AIC, Measurement of Air Kerma/ Exposure. Bragg-Gray theory, Mathematical expression describing Bragg-Gray principle and its derivation. Burlin and Spencer Attix Cavity theories. General definition of calibration factor - N_x , N_K , $N_{D,air}$, $N_{D,w}$. IAEA TRS277: Various steps to arrive at the expression for D_w starting from N_x . TRS398: $N_{D,w,Q}$; $N_{D,w}$; K_{Q,Q_0} ; K_Q . Derivation of an expression for K_{Q,Q_0} . Calorimetric standards. Measurement of D_w for External beams from ^{60}Co teletherapy machines, Linac: Reference conditions for measurement, Type of ion chambers, Phantom, Waterproof sleeve, Derivation of an expression for Machine Timing error. Beam Quality Index Measurement.

RADIATION DETECTION AND MEASUREMENT

Principles of Radiation detection and measurement - Basic principles of radiation detection (Gas Filled detectors - Ionization chambers - Theory and design - Construction of condenser type chambers and thimble chambers, Gas multiplication - Proportional and GM Counters (Characteristics of organic and inorganic counters - Dead time and recovery time Scintillation detectors - Semiconductor detectors - Chemical systems, Radiographic and Radio-chromic films, Thermoluminescent Dosimeters (TLD), Optically stimulated Luminescence dosimeters (OSLD), Radio-photoluminescent dosimeters - Neutron Detectors, Nuclear track emulsions for fast neutrons - Solid State Nuclear track (SSNTD) detectors, Calorimeters, New Developments. Dosimeters based on condenser chambers - Pocket chambers - Dosimeters based on current measurement - Different types of electrometers - MOSFET, Vibrating condenser and Varactor bridge types, Secondary standard therapy level dosimeters - Farmer Dosimeters, Radiation field analyzer (RFA). Water phantom dosimetry systems, Brachytherapy dosimeters, Thermoluminescent dosimeter readers for medical applications, Calibration and maintenance of dosimeters.

RADIOBIOLOGY

Biological Effects of Radiation: Somatic effects of radiation - Physical factors influencing somatic effects - Dependence on dose, dose rate, type and energy of radiation, temperature, anoxia, - Acute radiation sickness $LD_{50/60}$ dose, Effect of radiation on skin and blood forming organs, digestive tract - Sterility and cataract formation, Effects of chronic exposure to radiation, Induction of leukaemia, Radiation Carcinogenesis, Risk of carcinogenesis, Animal and human data - Shortening of life span, In-utero exposure, Genetic effects of radiation, Factors affecting frequency of radiation induced mutations, Dose-effect relationship, first generation effects, Effects due to mutation of recessive characteristics, Genetic burden, Prevalence of hereditary diseases and defects, Spontaneous mutation rate, Concept of doubling dose and genetic risk estimate. Biological basis of Radiotherapy: Physical and biological factors affecting cell survival, tumor regrowth and normal tissue response - Non-conventional fractionation scheme and their effect of reoxygenation, repair, redistribution in the cell cycle, High LET radiation therapy, Time dose fractionation, Linear and Linear Quadratic models.

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Hassan

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Sam

DIAGNOSTIC RADIOLOGY

Physical principle of diagnostic radiology: Interactions, differential transmission of x-ray beam, spatial image formation, visualization of spatial image, limitations of projection imaging technique. Radiography techniques: Prime factors (kVp, mAs and SID/SFD), influence of prime factors on image quality, selection criteria of prime factors, Filters, Scatter reduction: Factors influencing scatter radiation, objectives of scatter reduction, contrast reduction factor, scatter reduction methods; beam restrictors (diaphragms, cones/cylinders & collimators), grids. Intensifying screens and their Function, Radiographic Film: Components of radiographic film, Image quality: Image quality parameters. Xero-radiography, mammography, Interventional radiology, digital radiography (CR and DR systems), digital subtraction techniques, Conventional tomography (principle only), orthopan tomography (OPG), Computed Tomography (CT), QA of CT equipment, Magnetic Resonance Imaging (MRI) and Ultrasound Imaging (USG).

NUCLEAR MEDICINE

Introduction to Nuclear Medicine, Unsealed Sources, Production of Radionuclide used in Nuclear Medicine; Reactor based Radionuclides, Accelerator based Radionuclides, Photonuclear activation, Equations for Radionuclide Production, Radionuclide Generators and their operation principles. Various usages of Radiopharmaceuticals. In-vivo Non-imaging procedures; Thyroid Uptake Measurements, Renogram, Life Span of RBC, Blood Volume studies, Life Span of RBC etc. General concept of Radionuclide Imaging and Historical developments. Radionuclide Imaging: Other techniques and Instruments; The Rectilinear Scanner and its operational principle, Basic Principles and Design of the Anger Camera / Scintillation Camera; System components, Detector System and Electronics, Different types of Collimators, Design and Performance Characteristics of the Converging, Diverging and Pin hole Collimator, Image Display and Recording Systems, Digital Image Processing Systems, Scanning Camera, Physics of PET and Cyclotron: Principles of PET, PET Instrumentations. Treatment of Thyrotoxicosis, Thyroid cancer with ^{131}I , use of ^{32}P and ^{90}Y for palliative treatment, Radiation Synovectomy and the isotopes used. Concept of Delay Tank and various Waste Disposal Methods used in Nuclear Medicine. Planning and Shielding Calculations during the installation of SPECT, PET/CT and Medical Cyclotron in the Nuclear Medicine Department.

RADIOTHERAPY

Benign and Malignant tumors, palliative and curative therapy, beam therapy Equipments, low kV therapy x-ray units, telecobalt units - source design - beam collimation and penumbra - trimmers and breast cones, Design and working of medical electron linear accelerators - beam collimation - asymmetric collimator - multileaf collimator. Output calibration of ^{60}Co gamma rays, high energy x-rays and electron beams using IAEA TRS-398. Central axis dosimetry parameters-PDD, TAR, TMR, SAR and SMR. Beam Modifying devices. Target volume definition and dose prescription criteria- ICRU 50, 62 and 82 - SSD and SAD set ups. Depth dose characteristics and Clinical application of x-rays, gamma-rays, electrons and high LET radiations. Special techniques in radiation therapy -TBI, TSET, electron arc treatment and dosimetry, intraoperative radiotherapy, 3DCRT, IMRT, IGRT SRS, SBRT and adaptive Radiotherapy. Quality assurance of Radiotherapy units.

Shayla Javab

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RPd

Sanjay

Brachytherapy techniques - surface mould, intracavitary, interstitial and intraluminal techniques. Afterloading techniques - Advantages and disadvantages of manual and remote afterloading techniques. Requirement for brachytherapy sources. Description of radium and radium substitutes - ^{137}Cs , ^{60}Co , ^{192}Ir , ^{125}I and other commonly used brachytherapy sources. Dose rate considerations and classification of brachytherapy techniques, Low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR). Paterson Parker and Manchester Dosage systems. ICRU 38 and 58 protocols. Specification and calibration of brachytherapy sources - RAKR and AKS-IAEA TECDOC 1274 and ICRU 72 recommendations. Point and line source dosimetry formalisms - Sievert Integral AAPM TG-43 and other dosimetry formalisms.

RADIATION SAFETY AND RADIATION PROTECTION STANDARDS

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards - Historical background, International Commission on Radiological Protection and its recommendations. The system of Radiological Protection: Justification of Practice, Optimization of Protection and individual dose limits, Radiation and tissue weighting factors. Categories of exposures, Occupational, Public and Medical Exposures. Evaluation of external radiation hazards, Effects of distance, time and shielding- Shielding calculations - Personnel and area monitoring, Internal radiation hazards: Radio toxicity of different radionuclides and the classification of laboratories, Control of contamination.

Planning of medical radiation installations - General considerations, Design of diagnostic, deep therapy, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories. Evaluation of radiation hazards in medical diagnostic therapeutic installations - Radiation monitoring procedures - Protective measures to reduce radiation exposure to staff and patients. Radioactive waste management. Handling of patients Waste disposal facilities - Radiation safety during source transfer operations. Special safety features in accelerators, reactors, sources of radioactive wastes - Classification of waste, Disposal of radioactive wastes, Treatment techniques for solid, liquid and gaseous effluents - Permissible limits for disposal of waste Sampling techniques for air, water and solids - Geological, hydrological and meteorological parameters - Ecological considerations. Transportation of radioactive substances, packages, General packing requirements, Transport documents, Labeling and marking of packages, Regulations applicable for different modes of transport. Physical protection of sources. Radiation Emergencies and their Medical Management. National Legislation, regulatory framework, relevant regulatory documents such as Act, Rules, applicable safety codes, Standards, guides and manuals, radiation surveillance procedures. Regulatory requirements. ICRP and its recommendations, Categories of radiation exposures, risk factors, international/ national radiation protection standards- ICRP, BSS and AERB recommendation. UNSCEAR recommendations, factors governing internal exposure.

RADIATION EMERGENCIES AND EMERGENCY RESPONSE/PREPAREDNESS

Radiation accidents and emergencies in the use of radiation sources and Equipments in radiotherapy, Nuclear Medicine, diagnostic radiology and industries. Radiation injuries and Medical Management. Normal and Potential Exposures. Elements of emergency planning and preparedness.

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Harris

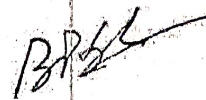
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