RAJASTHAN PUBLIC SERVICE COMMISSION, AJMER

SYLLABUS OF COMPETITIVE EXAMINATION FOR THE POST OF ASSISTANT PROFESSOR (Broad Speciality) RADIATION ONCOLOGY/RADIOTHERAPY MEDICAL EDUCATION DEPARTMENT

Unit-I - BASIC SCIENCES:

- **Anatomy -** Anatomy pertaining to Oncology, Cross-sectional anatomy, Relationship of vital structures.
- **Pathology -** General Pathology pertaining to oncology - Malignant transformation, Criteria for tumor diagnosis, macroscopic, histological & cytological uses & value of biopsy material, Tumor Markers, Cytogenetics, Molecular Pathology, and Immunohistochemistry, Classification of tumors - histogenic, histological, behavioral & immunological. Nomenclature - solid tumors, lymphomas, leukemias Endocrine aspects of malignancy: - production of hormones by tumors, the effect of hormones on tumors, paracrine effects of tumors. Paraneoplastic syndromes, Etiology of cancer, Tumor immunology.
- **Radiation Oncology Physics -**
  - *Structure of Matter:* Constituents of atoms, Atomic and mass numbers, Atomic and mass-energy units, Electron shells, atomic energy levels, Nuclear forces, nuclear energy levels, Nuclear binding energy.
    Electromagnetic radiation, Electromagnetic spectrum, Energy quantization, Relationship between Wavelength, Frequency, Energy.
  - *Nuclear Transformations:* Natural and artificial radioactivity, Alpha and Beta decay, Decay constant, Activity, Physical, Biological and Effective half-lives, Mean life, Decay processes, Radioactive series, Radioactive equilibrium.
  - *Production of X-rays:* The X-ray tube, X-ray circuits, Physics of X-ray production, Continuous spectrum, Characteristic spectrum, Efficiency of X-ray production, Distribution of X-rays in space, Specifications of beam quality, Measurement of beam quality, Filters, and filtration.
  - *Interaction of radiation with matter:* Attenuation, Scattering, Absorption, Transmission, Attenuation coefficient, Half Value Layer (HVL), Energy transfer, Absorption, and their coefficients. Photoelectric effect, Compton Effect, Pair-production, Relative importance of different attenuation processes at various photon energies.
    Electron interactions with matter: Energy loss mechanisms-Collisional losses, Radiative losses, Ionization, Excitation, Heat production, Delta rays, Polarization effects, Scattering, stopping power, Absorbed dose, secondary electrons.
    Interactions of charged particles: Ionization vs. Energy, Stopping power, Linear Energy Transfer (LET), Bragg curve, Definition of particle range.
  - *Measurement of radiation:* Radiation Detectors: Gas, Solid-state, Scintillation, Thermoluminescence, Visual Imaging (Film, Fluorescent screens), and their examples.
    Exposure, Dose, Kerma: Definitions, Units (Old, New), Inter-relationships between units, Variation with energy and material. Measurement of exposure (Free air chamber, Thimble chamber), Calibration of therapy beams: Concepts, Phantoms.
    Quality assurance checks on radiation therapy units.

Protocols (TG 21, IAEA TRS-277, TG 51) Dose determination in practice *(brief outline only, details not required)*

- *Radiotherapy Equipment:* Grenz ray, Contact, Superficial, Orthovoltage or Deep therapy, Super voltage, Megavoltage therapy. Therapy and diagnostic X-ray units – comparison.
  Filters, factors affecting output, principles of cooling. Betatrons.
  Co-60 units: Comprehensive description of the unit, Safety mechanisms, Source capsule.
  Linear accelerators: History, Development, Detailed description of a modern, dual mode linear accelerator, Linac head, and its constituents, Safety mechanisms, Computer-controlled linacs, Record and Verify systems, Relative merits and demerits of Co-60 and linac units, *Betatrons, Cyclotrons:* for neutron therapy, *Simulators:* Need for them, Detailed description of a typical unit, Simulator CT.
- *Basic ratios, Factors, Dose distributions, Beam modifications and Shaping in Teletherapy beams.*
  Characteristics of photon beams: Quality of beams, Difference between MV and MeV, Primary and scattered radiation.
  Percentage depth dose, Tissue-Air Ratio, Scatter Air Ratio, Tissue-Phantom Ratio, Tissue Maximum Ratio, Scatter Maximum Ratio, Back Scatter Factor, Peak Scatter Factor, Off-Axis Ratio, Variation of these parameters with depth, field size, source-skin distance, beam quality or energy, beam flattening filter, target material. Central, axis depth dose profiles for various energies.
  Equivalent square concept, Surface dose (entrance and exit), Skin sparing effect, Output factors.
  Practical applications: Co-60 calculations (SSD, and SAD technique), Accelerator calculations (SSD, and SAD technique)
  Beam profiles, Isodose curves, Charts, Flatness, Symmetry, Penumbra (Geometric, Transmission and Physical), Field size definition.
  Body inhomogeneities: Effects of patient contour, Bone, Lung cavities, Prosthesis on dose distribution. Dose within bone / lung cavities, Interface effects, Electronic Disequilibrium, Wedge filters and their use, Wedge angle, Wedge Factors, Wedge systems (External, In-built Universal, Dynamic / Virtual), Wedge isodose curves other beam modifying and shaping devices: Methods of compensation for patient contour variation and/or tissue inhomogeneity- Bolus, Build up material, Compensators, Merits and Demerits. Shielding of dose-limiting tissue: Non-divergent and Divergent. beam blocks, independent jaws, Multileaf collimators, Merits and Demerits.
- *Principles of Treatment Planning - I*
  Treatment planning for photon beams: ICRU 50 and relevant ICRU reports and NACP terminologies. Determination of body contour and localization: Plain film, Fluoroscopy, CT, MRI, Ultrasonography, Simulator based Methods of correction for beam‟s oblique incidence, and body inhomogeneities. SSD technique and isocentric (SAD) technique: Descriptions and advantages of SAD technique. Combination of fields: Methods of field addition, Parallel opposed fields, Patient thickness vs. Dose uniformity for different energies in a parallel opposed setup, Multiple fields (3 fields, 4 field box, and other techniques). Examples of above arrangements of fields in SSD and SAD techniques, Integral Dose, Wedge field technique, Rotation Therapy (Arc, and Skip), Tangential fields. Beam balancing by weighting. Total and Hemi-body irradiation. Field junctions.

- *Principles of treatment planning – II*
  Limitations of manual planning. Description of a treatment planning system (TPS) : 2D and 3D TPS. Beam data input, Patient data input (simple contour, CT, MR data, Advantages of transfer through media), Input devices (Digitizer, floppies, DAT devices, Magneto-optical disks, direct link with CT, MR). Beam selection and placement, Beam‟s Eye View (BEV), Dose calculation and display (Point dose, Isodose curves, Isodose surfaces, Color wash). Plan optimization, Plan evaluation tools: Dose-Volume Histograms (Cumulative and Differential), Hard copy output, Storage and retrieval of plans.
  Alignment and Immobilization: External and internal reference marks, Importance of immobilization in radiotherapy, Immobilization methods (Plaster of Paris casts, Perspex casts, bite block, shells, headrests, neck rolls, Alpha-Cradles, Thermoplastic materials, *polyurethane foams),* Methods of beam alignment (isocentric marks, laser marks, and front/back pointers).
  Treatment execution: Light field, Crosshair, ODIs, Scales in treatment machines. *Treatment verification:* Port films, electronic portal imaging devices, In-vivo patient dosimetry (TLD, diode detectors, MOSFET, Film, etc.) Changes inpatient position, target volume, and critical volume during the course of treatment.
- *Electron Beam Therapy*
  Production of electron beams: Production using accelerators, Characteristics of electrons. Surface dose, percentage depth dose, beam profiles, Isodose curves and charts, Flatness and Symmetry. Beam collimation, the variation of percentage depth dose and output with field size, and SSD, photon contamination. Energy spectrum, Energy specification, the variation of mean energy with depth. Suitability of measuring instruments for electron beam dosimetry.
  Treatment planning: Energy and field size choice, air gaps, and obliquity, Tissue inhomogeneity – lung, bone, air-filled cavities. Field junctions (with either electron or photon beam). External and internal shielding. Arc therapy, Use of the bolus in electron beam. Total Skin Electron Irradiation, Intraoperative Radiation Therapy.
- *Physical Principles of Brachytherapy:* Properties of an ideal brachytherapy source, Sources used in brachytherapy: Ra-226, Cs-137, Ir-192, Au-198, Co-60, I-125, Sr-90, Yt-90, Ru-106, Ta-182, and other new radionuclides, They're complete physical properties, Radium hazards. Source construction including filtration, comparative advantages of these radionuclides Historical background. Radiation and Dose units: Activity used, Exposure, Absorbed Dose, mg-hr, curie, milli-curie destroyed, milligram Radium equivalent, roentgen, rad, gray. Source strength specification, Brachytherapy Dose calibrator.
  Techniques: Pre-loaded, After loading (manual and remote), Merits and Demerits. Surface, Interstitial, Intracavitary, Intraluminal, Intravascular brachytherapy. Low, Medium, High and Pulsed dose rates. Remote after loading machines, Detailed description of anyone unit.
  Dosage systems: Manchester System (outline only), Paris System (working knowledge).
  Treatment Planning: Patient selection, Volume specification, Geometry of implant, Number, Strength, and Distribution of radioactive sources, Source localization, Dose calculation, Dose rate specification, Recordkeeping. ICRU 38.
  Radiation Safety: Planning of brachytherapy facility, Rooms, and equipment, Storage and Movement control, Source inventory, Disposal, Regulatory requirements, Beta-ray brachytherapy including methods of use, inspection, storage and transport of sources, dose distribution.
  Unsealed radionuclides: Concepts of uptake, distribution, and elimination, Activities

used in clinical practice, Estimation of dose to target tissues, and critical organs, Procedures for administering radionuclides to patients.

- *Quality Assurance in radiotherapy (QART)*
  Overview of ESTRO QART: Need for a quality system in Radiotherapy, Quality System: Definition and practical advantages, Construction, Development, and Implementation of a Quality System.
  Quality Assurance of Simulator, TPS, Co-60, linear accelerator. Acceptance testing of Simulator, TPS, Co-60, linear accelerator.
- *Radiation Protection from External and Internal sources and Regulatory Aspects: Statutory Framework* – Principles underlying International Commission on Radiation.
  Protection (ICRP) recommendations. ICRP and National radiation protection i.e. Atomic Energy Regulatory Board (AERB) standards. Effective dose limits (ICRP and AERB).
  Protection mechanisms: Time, Distance and Shielding. Concept of "As Low As Reasonably Achievable" (ALARA).
  Personnel and Area Monitoring: Need for personnel monitoring, Principles of film badge, TLD badge used for personnel monitoring. Pocket dosimeter. Need for area monitoring, Gamma Zone monitors, Survey meters.
  Regulatory aspects: Procedural steps for installation and commissioning of a new radiotherapy facility (Teletherapy and Brachytherapy). Approval of the Standing Committee on Radiotherapy Development Programme. Type approval of unit. Site plan, Layout of installation/Associated facility: Primary, Secondary barriers, leakage, and scattered radiation. The regulatory requirement in the procurement of teletherapy/Brachytherapy source(s). Construction of the building, Qualified staff, Procurement of instruments, and accessories, Installation of unit and performance tests, Calibration of the unit, RP&AD approval for clinical commissioning of the unit.
  Other regulatory requirement s: Regulatory consent, NOCs, Periodical reports to AERB and Radiological Physics and Advisory Division (RP&AD), Bhaba Atomic Research Centre (BARC).
- *Advancements in Radiation Oncology:*
  Virtual Simulation: Principle, CT-Simulation, TPS based virtual simulation, Differences, Merits and Demerits, Practical considerations.
  Conformal radiotherapy (CRT): Principles, Advantages over conventional methods, Essential requirements for conformal radiotherapy.

Various methods of CRT:

1. With customized field-shaping using conventional coplanar beams
2. Multiple non-coplanar MLC beams conforming to a target shape
3. Stereotactic radiotherapy
4. Principle of Inverse planning and Intensity Modulated Radiation Therapy (IMRT)
   – Using 3D compensators
   – Static IMRT (Step and shoot technique)
   – Dynamic IMRT (sliding window technique)
   – Dynamic arc IMRT
   – Micro-MLC
   – Tomotherapy methods
5. Time gated (4D) radiotherapy, Merits and demerits of IMRT, Stereotactic irradiation methods: Physics principles, Techniques, Description of Units (Gamma Knife and Linac Based-Cyber Knife, Tomotherapy), Merits and demerits,

Stereotactic Radiosurgery (SRS) and Stereotactic Radiotherapy (SRT), Whole body stereotactic frame.

Networking in radiotherapy: Networking of planning and treatment units in a radiotherapy, department including Picture Archival Communication System (PACS), Advantages, Patient, Data Management.

- *Planning of a Radiotherapy Department*

Building designs, Choice of various types of equipment and sources, Acceptance and Calibration Tests, Various maintenance steps and procedures.

- **Radiobiology**
  - Introduction to Radiation Biology.
  - Radiation interaction with matter.
  - Introduction to factors influencing radiation response.
  - The relevance of radiation biology to radiotherapy.
  - Interaction of ionizing radiation on mammalian cells.
  - Organ radiosensitivity and radio responsiveness, the concept of therapeutic index.
  - Acute effects on Radiation.
  - Radiation Effects on Major Organs/tissues.
  - Late effects of radiation (somatic).
  - Late Effects of Radiation (Genetic).
  - Effects of Radiation on Human Embryo & Fetus.
  - Biology and Radiation Response of Tumors.

- **Applied Radiobiology**

Fractionation: rationale, factors involved (4 R‟s).

Time, dose, and fractionation relationship: isoeffect curves, isoeffect relationships, e.g. NSD, CRE formalisms and their limitations, partial tolerance, means of summating partial tolerance, steepness of dose-response curves.

Multi-target, two-component and linear-quadratic model. a/b ratios for acute and late effects and means of deriving these values. Isoeffective formulae. Clinical applications of the L-Q model, hyperfractionation, accelerated fractionation, hypofractionation, CHART, split dose treatments.

Brachytherapy - low dose rate, high dose rate, and pulsed treatments.

Introduction to new techniques to optimize radio-curability; combination therapy (adjuvant surgery or chemotherapy), hyperthermia, hypoxic cell radio-sensitizes, high LET radiation. Photodynamic therapy.

The volume effect, general principles, and current hypotheses. Shrinking Field technique.

Combination Radiation -Surgery

Pre-, post- and intra-operative radiation.

Rationale, radiobiological factors, current clinical results.

Irradiation of sub-clinical disease, debulking surgery, the importance of clonogenic numbers.

Combination Radiation -Chemotherapy

Definitions of radio sensitizer, synergism, potentiation, antagonism. Radiosensitizers: types, mechanism.

Hyperthermia Sources, the rationale (historical examples), advantages and disadvantages, thermo tolerance.

Cellular damage: comparison and contrast with radiation, thermal and non-thermal effects of ultrasound, microwaves, radiofrequency, etc. General host responses (immunology, metastases).

Use along with radiotherapy and chemotherapy: optimum sequencing of combined modalities. Current limitations to the clinical use of hyperthermia.

- **High LET Radiation**

  Comparison and contrast with low LET radiation.

  Neutrons: source (including 252 Cf) and boron neutron capture (outline only). Advantages and disadvantages of neutrons, RBE values, hazards of low dose and low energy neutron, use in radiotherapy, combination with low LET, current clinical results.

  Other high LET particles: protons, mesons, high-energy heavy nuclei, application to radiotherapy, current clinical results.

- **Nuclear Medicine**
  - **Radiopharmaceuticals**

(a) Physical and Chemical Characteristics of radionuclide used in Nuclear Medicine.
(b) Radio pharmacy generator produced radiopharmaceutical.
(c) Criteria for selection of radionuclide.
(d) The biological behavior of radiopharmaceuticals.
(e) Quality control.
(f) Mechanism of localization.
(g) Radiopharmaceuticals for therapy.
(h) Positron Emission radio-nuclide their preparation, various modules of nuclear reactions, target reactions, and chemistry.
(i) Specific topics on Bone seeking Radiopharmaceutical, Hepatobiliary, Tumor seeking, Cardiac Imaging, Radiopharmaceuticals for Research, etc.

- **Therapeutic uses of Radionuclide**

Application of isotope in Therapy in the following areas:
1) Thyrotoxicosis
2) Cancer Thyroid – both low dose & high dose
3) Bone Palliation using P32, Sr 89 & Sm 153.
4) I-131 Lipidol for Hepatic cancer

- **Clinical trials - Statistical basis for planning & interpretation**

Clinical Trials.

– Advantages & disadvantages
– Retrospective & prospective studies
– Controlled & uncontrolled trials
– Single-blind & double-blind studies
– Phase I, II & III trials
– Ethics (Helsinki declaration).

Unit-II - CLINICAL RADIOTHERAPY:

- **Cancer Epidemiology & Etiology**
  - Cancer Statistics - worldwide & India
  - Cancer Registries & National Cancer Control Programme.
  - Analysis of data in cancer registries.
  - Regional Cancer Centers
  - Cancer Screening & Prevention.
- **Patient Care**
  - Assessment & referral systems for radiotherapy
  - Diagnosis & workup.
  - Staging.
  - Care & evaluation during & after treatment.
  - Emergencies in Oncology.
  - Management of different malignancies ie.

    Skin Cancer, Central Nervous System Tumor / Orbital Tumors / Spinal Tumors,

Head and Neck Tumors, Thoracic Tumors, Breast Tumors, Gastrointestinal Tumor, Liver, Gall bladder, bile duct, and pancreatic tumors, Pediatric Tumors, Gynecologic Tumors, Male Genitourinary Tumors, Urinary Tract Tumors, Endocrine Tumors, Hematological Malignancies –Leukemias, lymphomas and Plasma cell. Neoplasm Sarcomas of Bone and Soft tissues. Metastasis of Unknown Origin, AIDS-related Malignancies, Oncologic Emergencies.

Endocrine aspects of malignancy: - production of hormones by tumors, effect of hormones on tumors, paracrine effects of tumors Paraneoplastic syndromes, Benign Diseases, Hereditary cancer syndromes.

- **Techniques of Radiotherapy**
  - Small field beam directed therapy
  - Extended and irregular field therapy
  - Beam modification therapy
  - Rotation arc therapy
  - Intracavitary, interstitial and mold application
- **Treatment planning and presentation**
  - Mold room practices
  - Simulation
  - The computerized treatment planning system
  - Clinical dosimetry
  - Prescription and execution
- **Treatment Response & Result**
  - Guidelines for treatment response assessment - Complete Response, Partial Response, No Response, and Stable disease.
  - Endpoints of treatment results: Loco-regional control, recurrence, metastasis, survival, quality of life.
  - Treatment-related morbidity assessment
    (i) Radiation morbidity (early & late)
    (ii) Morbidities of combined treatment
    (iii) Grading Systems.

Unit-III - CLINICAL CHEMOTHERAPY:

- **Basic principles and clinical practice of chemotherapy**
  - Classification of Chemotherapy drugs.
  - Newer chemotherapeutic agents.
  - Clinical application of
    - Single drug therapy
    - Polychemotherapy and various combinations
    - Adjuvant therapy
    - Prophylactic therapy
  - Chemotherapy practice in various malignancies.
  - Chemotherapy practice & results/ toxicities in sequential & concomitant Chemo radiotherapy.
  - Supportive care for chemotherapy.
  - The basic principles underlying the use of chemotherapeutic agents.
    (i) Classification and mode of action of cytotoxic drugs. The principles of cell kill by chemotherapeutic agents, drug resistance, phase-specific, and cycle-specific action.
    (ii) Drug administration. The general principles of pharmacokinetics; factors affecting drug concentration „in vivo" including route and timing of

administration, drug activation, plasma concentration, metabolism, and clearance.

(iii) Principles of combinations of therapy, dose-response curves, adjuvant and neoadjuvant chemotherapy, sanctuary sites, high dose chemotherapy, and regional chemotherapy.

(iv) Toxicity of drugs. Early, intermediate and late genetic and somatic effects of common classes of anticancer drugs. Precautions in the safe handling of cytotoxic drugs.

(v) Endocrine manipulation and biological response modifiers. An understanding of the mode of action and side effects of common hormonal preparations used in cancer therapy (including corticosteroids). Use of the major biological response modifiers such as interferon‟s, interleukins, and growth factors and knowledge of their side effects.

(vi) Assessment of New Agents. Principles of phase I, II, and III studies.

(vii) Gene Therapy

- Immuno therapy- Clinical application and uses in various malignant conditions, toxicity and toxicity management.

Unit-IV - Other Disciplines Allied to Radiotherapy and Oncology:

- ***Principles and Practice*** of general surgery, gynecology and pediatric Surgery as related to cancer.
- Basic principles of surgical oncology, biopsy, conservation surgery, radical surgery, palliative surgery.
- Methods of Clinical staging and TNM classification.
- Basics of surgical techniques - head & neck, breast, thorax, abdomen, gynecological, genitourinary, musculoskeletal, CNS.
- Combined treatments: with radiotherapy, chemotherapy, and hormone therapy.
- Preventive oncology
- Prevention and early detection of cancer.

Unit-V - PALLIATIVE CARE:

- Guidelines for palliative care
- Symptoms of advanced cancer
- Management of terminally ill patients.
- Different pharmacologic & non-pharmacologic methods
- Pain control, WHO guidelines for adults & children.
- Palliative radiotherapy
- Palliative chemotherapy
- Home care
- Hospice care
- Physical, social, spiritual & other aspects.

Unit-VI - Research, Training and Administration:

- **Research in Oncology**
  - How to conduct research
  - Guidelines for biomedical research: Animal studies, drug studies, human trial.
  - Cancer clinical trials. Phase I /II/III
  - Ethics of clinical research
  - Evidence-based medicine.

- **Administration Radiotherapy and Oncology.**
  - Clinical Oncologists‟ role as an administrator.
  - How to set up a Radiotherapy and Oncology department, planning of infrastructure & Equipment.
  - Cancer registry and epidemiology
  - Role in the cancer control program, Cancer screening programs
  - Responsibilities towards safety & quality assurance.
- **Special topics**
  - Oncological Emergencies
  - TLI, Extracorporeal irradiation (ECI) and TBI – Role and Techniques
  - Radiation treatment of benign diseases and tumor-like conditions
  - Preventive Oncology
- **New Radiation Modalities**
  - Protons therapy
  - Neutron therapy
  - Pions therapy
  - High energy heavy ions (Carbon and others) therapy
  - Hyperthermia

*** * * * ***

Pattern of Question Papers:

1. **Objective Type Paper**
2. **Maximum Marks: 150**
3. **Number of Questions: 150**
4. **Duration of Paper: 2.30 Hours**
5. **All Questions carry equal marks**
6. **There will be Negative Marking**

   (**For every wrong answer one-third of the marks prescribed for that Particular question shall be deducted.)**