Colour Coding
Global GREEN
Regional BLUE
National ORANGE
Local (State) PINK

Agenda item # 2: Revision of the Syllabus of Radiation Oncology

Existing program:

The existing program encompasses the current NMC guidelines, and is as follows-

Guidelines for Competency Based Postgraduate Training Programme for MD in Radiotherapy

Programme Outcomes:

The purpose of PG education is to create specialists who would provide high quality health care and advance the cause of science through research & training. Oncology is a highly specialized and technical discipline in clinical medicine comprising treatment with ionizing radiations and cytotoxic agents as major arms in non-surgical management and treatment of cancer. The radiation oncologists will be trained to have a sound understanding of the scientific principles that underlie cancer and the treatments they prescribe including cancer biology, pharmacology of systemic anti-cancer therapies, radiobiology, radiation physics and interpreting research results to inform decision-making.

With a view to update, by inclusion of newer topics, and to provide a uniform syllabus and course contents in Indian universities and teaching medical institutions, the proposed guidelines provide course outlines based on recent developments in clinical medicine and other disciplines related to oncology.

1. The trainee shall acquire skills in various aspects of theoretical, clinical and practical realms of Radiotherapy, basic cytotoxic chemotherapy and palliative care to enable the MD student them to offer skill-based diagnostic, curative, palliative and preventive care of the highest professional standards.
2. The knowledge and attitudes imparted during the program shall enable the MD student to work as an independent clinician, teacher and researcher who is well versed with diagnostic and therapeutic acumen and research methodologies pertaining to radiotherapy & oncology.
3. Such an extensive training shall cater to the health care needs of patients of cancer at the **local, regional and national levels and help deliver quality care of international standards to our population.**

Given the pace of change in oncology, the curriculum will provide trainees with the aptitude for continual professional development including taking an active role in clinical trials and adopting appropriate technology, skills and treatments.

A post graduate student pursuing MD (Radiotherapy) course will acquire **adequate knowledge related to**

(a) Basic Sciences as applied to Radiotherapy and Oncology so that the student is at par with national and international counterparts to help acquire focused and knowledge based understanding about the common and rare clinical diseases related to different aspects of Oncology

(b) Clinical, experimental, investigative and management issues applied to non-surgical aspects of Cancer to gain comprehensive proficiency related to etio-pathogenesis, anatomy, physiology, and the diverse clinical spectrum of oncology. The familiarity with local prevalent disease trends and

management practices shall help the MD trainees serve their region, state, and country in a need-based and cost-effective manner.

(c) Awareness about recent advances in field of Radiotherapy and Oncology with up-to-date skill and knowledge to apply skill based intellectual decision based management algorithms to benefit the region, state, and country.

(d) Contribute to the field of Radiotherapy and Oncology by imparting training to colleagues, teaching future students, and getting involved in research.

Subject Specific Learning Objectives

During the MD program of Radiotherapy, a student will acquire enough theoretical and practical knowledge for competent, safe, compassionate & ethical practice of oncology and should contribute to the future developments in radiation oncology in the state, country and globally.

1. Knowledge in the basic, comparative, translational, and clinical oncology, to understand the disease burden, distribution, determinants of cancer illness in the region and country.
2. Clinical, diagnostic, critical thinking, problem solving, self-directed learning and procedural skills required in the treatment of common cancers such as breast, head & neck besides others which are prevalent in the state or country.
3. Demonstrate the ability to diagnose and treat all cases of malignancies using updated guidelines in medical and radiation oncology with special ability to maintain inter disciplinary coordination.
4. A high level of technical expertise in all forms of radiation as a therapeutic tool used in radiotherapy and knowledge of the adverse effects of radiation including radiation related accompaniments including basic cytotoxic drugs and relevant palliative care.
5. A sound capability to manage cancer patients as a whole, including
    a) The complications associated with malignant diseases & its management
    b) Psychosocial problems
    c) Rehabilitation& palliative care
6. Demonstrate the ability to address all emotional issues in patients and family members in relation to diagnosis, therapy, terminal care and mortality related to malignancies.
7. Organise proper promotive and preventive care strategies in the community aimed at reducing the burden of care in malignancies in the region and nationally.
8. Lead and participate in planning and execution of team work related to establishment and maintenance of infrastructure related to radiation therapy, conforming to the updated guidelines.
9. Skills as related to formulating research questions, initiating, conducting, and analyzing translational, clinical and epidemiologic research. The students shall focus on research oriented toward ease of access, lower the cost of treatment, novel treatment, and prevention of the common cancers in the country and region such as breast, cervix, and head neck. At the same time these illnesses are also of international concern.
10. Communication skills necessary for working with and educating patients and team members at local, national, regional, and internal forum.
11. Attitudes and values that will allow him or her to provide compassionate, responsive, and respectful ethical care to the patient.

12. Demonstrate the ability to organise teaching / training sessions for students and health workers in topics related to cancer prevention and care to train the medical fraternity in the state, country, and region.
13. Attain a quality of specialty training, comparable to the best of standards where after obtaining MD (Radiotherapy) the individual is competent to
    a) Provide best of care to cancer patients
    b) Set up the department of Radiotherapy and Oncology in different parts of India
    c) Interact with the Government machinery & other agencies as a nodal person for developments in oncology.

The student is expected to gain knowledge in the following FOUR key areas:

A. Theoretical Knowledge:

- The student will acquire knowledge in all aspects relevant to the practice of common cancers, including Head neck, cervix and breast, in the state, country, and region. This includes training and expertise in Radiotherapy capable of providing specialist care to our citizens, being a teacher and guiding researcher in Radiotherapy, to promote the cancer research in the state, region and the country.
- She/ He will acquire and be able to impart necessary knowledge, skill, and attitudes to diagnose and manage in a cost-effective manner to solve various clinical problems commonly seen in the local community and at secondary and tertiary care centers of the region and country. Special emphasis should be placed on preventive oncology to reduce the disease burden in the region.

B. Teaching skill

- The student will be able to teach relevant aspects of cancer treatment and care to resident doctors, junior colleagues, nursing and para-medical staff to enhance the skilled work force at local level.

C. Research methodology

- Student will be able to identify and investigate a research problem, prevailing in the local community or state or country, using appropriate methodology.

D. Group approach

- Student will participate in multi-disciplinary meetings with experts in, Surgical Oncology, Medical Oncology, Radiology, Nuclear Medicine, Pathology, other surgical disciplines such as Gastrosurgery, Neurosurgery, Endocrine Surgery, Paediatric surgery, Urology, Gynaecology etc and Laboratory Medicine, and other allied clinical disciplines. This will help them to integrate acquired knowledge and apply aptly.

Subject Specific Competencies

The objectives of the MD programme in Radiotherapy (Is it possible to use one term, either Radiation Oncology or Radiotherapy) is to impart knowledge, practical skills and clinical experience in the non-surgical treatment of cancer. **At the end of the course, the MD student will acquire the following competencies under the following three domains:**

A. Cognitive domain

The students, after successful completion of their training, should have acquired knowledge in the following:

1. Theoretical and practical knowledge for competent, safe, compassionate & ethical multidisciplinary practice of oncology and should contribute to the future developments in oncology.
2. The epidemiology, etiology, pathology & natural history of human neoplastic diseases.
3. Knowledge, experience & skill in the clinical diagnosis of human neoplastic diseases.
4. Attain knowledge and a high level of technical expertise in all forms of radiation as a therapeutic tool used in radiotherapy
5. Knowledge of the adverse effects of radiation including radiation related accompaniments.
6. Knowledge and comprehension & skill regarding the use of cytotoxic drugs and biological response modifiers in all clinical and research settings with detailed knowledge of adverse effects of these drugs.
7. Knowledge and comprehension with the role of surgery in the management of neoplastic diseases.
8. Knowledge and ability to judiciously combine various modalities in comprehensive, multi-disciplinary management of cancer patients; coordinate with other specialty experts in the team and plan for use of radiation and cytotoxic drugs integrated into the overall treatment plan including palliative and end-of-life-care.
9. A sound knowledge and capability to manage cancer patients as a whole, including
    a) Management of oncological emergencies
    b) Complications associated with malignant diseases and its management
    c) Psycho-social problems
    d) prevention, rehabilitation and palliative care
10. Knowledge and capacity to interpret current advances in cancer management and research (basic, clinical and applied aspects of research including radiobiology & molecular oncology).
11. Knowledge and capability to plan and coordinate community based screening, early detection, and awareness programmes including community-based research projects.
12. Basic knowledge of the different statistical methods used in collection, analysis and interpretation of data related to cancer (with special emphasis on planning & interpretation of clinical trials)
13. Knowledge and capability to set up the specialty department and facilities for Oncology in different parts of India.
14. Able to interact with the Government and other agencies as a nodal person for planning development of specialty of radiation oncology.
15. A broad knowledge of different types of investigations in the management of patients with

cancer.

B. ***Affective Domain*** (Attitudes including Communication and Professionalism):

The student:

1. Should be able to function as a part of a team, develop an attitude of cooperation with colleagues, and interact with the patient and the clinician or other colleagues to provide the best possible diagnosis or opinion.
2. Always adopt ethical principles and maintain proper etiquette in dealings with patients, relatives and other health personnel and to respect the rights of the patient including the right to information and second opinion.
3. Develop communication skills to word reports and professional opinion as well as to interact with patients, relatives, peers and paramedical staff, and for effective teaching.
4. Demonstrate kindness, empathy and compassion towards all patients and their families & treat all patients in a holistic manner and respect the patients' right to information and second opinion.
5. Communicate well with patients and make all efforts to explain the rationale of diagnostic and treatment approach to patients and their caregivers in their own language for ease of understanding & spend time with patients explaining to them with thoughtfulness and empathy the pros and cons all options and further course of action.
6. Have the skills to participate in seminars, Continuing Medical Education programs, panel discussions, lectures to discuss and review recent scientific data to further the cause of Radiotherapy & Oncology in the country and increase visibility on national and global platforms.
7. Should have the ability to pass on such information and knowledge gained to other students and colleagues, especially those working in resource-limited settings to improve cancer care of the region, state and country.
8. Should actively cultivate skills to work in a team, with mutual respect, basic human courtesy and a supportive attitude towards others including other clinicians, para-clinical staff, policy makers and health administrators to improve cancer services at a regional, state and national level.
9. Communicate openly and honestly with all patients and their caregivers, hospital administrators, regulatory authorities, peers and researchers of the oncology fraternity and other allied members of the public and community leaders
10. Develop a habit of maintaining honest, detailed and comprehensive medical records.
11. Maintain principles of etiquette and abide with the country's laws, adopting ethical practices at all times.
12. Be aware of ethical principles of clinical research as guided by institutional ethical committees.
13. Should demonstrate principles of equality when dealing with individuals of special groups.
14. Should be able to accept feedback and criticisms with an open mind.
15. As a skilled professional, be aware of the value of maintaining punctuality in clinical work

C. ***Psycho-motor domain***

The student, at the end of the course, should have acquired the following skills:

Skills and Clinical Experience: Considerable familiarity and skills in the application of imaging techniques, nuclear medicine procedures, pathology and other aids in the diagnosis and management of cancers.

Post graduate students need to have gained a wide range of experience in the areas of patient care which would include investigation, diagnosis, treatment with radiation, basic cytotoxic chemotherapy and skills in palliative and supportive care and to have gained the practical experience detailed below:

Radiotherapy & Oncology – Basic Techniques

i. *Positioning the Patient\Immobilisation Techniques*: Application of some of the following immobilisation techniques: head clamp, Velcro strap, polystyrene beads, vacuum bag, breast arm rest

ii. *Methods of Target Volume Determination*: performance of planning using direct vision of tumour (eg skin tumours),from surface landmarks (eg the parotid bed, breast tumours), with direct screening using simulator (eg lung tumours, bone metastases), including opacification techniques (eg barium swallow, cystogram),by volume transfer to orthogonal radiographs (eg head and neck tumours, brain tumours), Volume determination from planning CT scans for creating a central axis plan, off axis plans, for 3-dimensional CT planning and 4 D CT planning.

iii. *Outline Techniques*: Use of manual techniques (flexi-curves, plaster of Paris bandage) and CT derived outlines.

iv. *Basic Field Arrangements*: Planning of treatments (under supervision where necessary) using the following field arrangements: Single direct field, Opposed pair of fields using equal and unequal weightings, Opposed pair using wedges, Wedged right-angled pair, Wedged oblique pair, Plans using 3 and 4 fields, Conformal Radiotherapy planning, Intensity modulated treatment plans, Image guided treatment plans & Total body irradiation.

v. *Tissue Compensation*: Planning of patients requiring tissue compensation using bolus, wedges and remote tissue compensators; *Shielding*: Planning of patients using lead cut outs and lead masks for simple superficial tumours, Knowledge of the thickness of lead required for superficial, orthovoltage and electron treatments at various energies, prescription and insertion of eye shields.

vi. *Megavoltage Techniques*: Planning of patients incorporating simple lead blocking techniques using standard blocks and cast blocks from templates

vii. *Electrons*: The indications for, and planning of, electron treatments, including the selection of electron energy, A technique for total skin electron therapy and experience of its use.

viii. *Dose Calculation*: Proficiency in the use of equivalent square tables, performance of depth dose calculations for single fields and opposed fields using various energies; The principles applied to convert dose to machine units for a range of machines; The principles of computer based treatment planning.

ix. *Radiotherapy Prescriptions*: Writing radiotherapy prescriptions (countersigned where necessary) for all the field arrangements mentioned above. Understanding of dose specification as in ICRU 50, 62, 83 etc.

x. *Radiotherapy Machines*: Planning of patients for treatment on a full spectrum of equipment, including superficial x-ray therapy, megavoltage x-ray therapy and megavoltage electron therapy (also orthovoltage x-ray therapy and cobalt-60 therapy, if available), modern linear accelerators, including tomotherapy and robotic systems as available.

xi. *Quality Assurance in External Beam Therapy*: Interpreting portal imaging (planar and volumetric cone beam CT images) to implement appropriate set-up correction strategies in all sites. Principles of in vivo dosimetry and interpretation of results.

xii. *Brachytherapy*; The insertion and removal of radioactive sources manually or using an appropriate after-loading device, Interpretation of subsequent check films, Interpretation of the corresponding dose calculation and writing of an appropriate prescription, Removal of live sources and the after-loading device, The placement of implants, Principles of oral and intravenous radionuclide therapy. Image guided brachytherapy and template brachytherapy.

xiii. *Safe delivery* of basic cytotoxic chemotherapy, especially in the concurrent settings and when required for palliation.

xiv. *Radiation Safety*: The role of the radiation safety and radiation protection supervisor; The meaning of and requirements for controlled and supervised areas and their location. The procedure to be adopted in the case of a spill of radioactive material; Quality assurance practices in radiotherapy and the procedures for dealing with errors in treatment delivery.

Radiotherapy Assessment and the Care of Patients on Treatment:

i. *Treatment Review Clinics;* Regular weekly treatment review clinics and interventions to support patients during radiation – day care or indoor admissions, appropriate cross referrals, including appropriate first response to any emergencies of patients on treatment.

ii. *Treatment Checks:* Assessment of patient position and treatment field placement(s) in relation to the target volume at the start of treatment, Performance of checks during the course of treatment on the implementation of the treatment plan, position of shielding for critical normal structures and the use of portal imaging; Assessment of changes occurring in patient parameters during treatment and resultant modification of treatment when appropriate; Assessment of normal tissue reactions to radiotherapy; Use of in vivo radiation dosimetry techniques.

iii. *Symptom Control:* Giving advice on skin care during radiation treatment and on the management of skin reactions, including desquamation, Managing mucosal reactions in oral cavity, oropharynx, nasopharynx, trachea, oesophagus, anus and vagina; Recognising consequences of radio-chemotherapy treatments in the upper aero-digestive tract that result in decreased intake of food and water including aspiration risks and management of the same; Giving dietary advice during radiotherapy; Managing radiation induced nausea and vomiting, diarrhoea, dysphagia, xerostomia and cystitis; Giving prophylaxis for radiation induced cerebral oedema; Giving advice on timing and extent of hair loss with respect to radiation dose; Hospitalisation and symptom management as needed.

iv. *Follow-up:* Managing acute and chronic radiation sequelae, in all regions of the human body – brain, face & neck (xerostomia, otitis externa / media; dental care cross referrals), pneumonitis, pericarditis, cardiac insufficiency & esophageal strictures; hepatic & chronic bowel complications, gynaecological sequelae (vaginal stenosis, vaginal dryness, infertility and dyspareunia) and appropriate cross referrals to specialists as needed.

Supportive and Palliative Care

i. *Pain Relief*

a. Drug treatment: A wide range analgesic techniques, including simple analgesics, mild and strong opioids, given by a variety of routes, Management of the complications of analgesics, including constipation, nausea, gastro-intestinal discomfort and analgesic intolerance.

b. Mechanical methods; Prescription, and evaluation of TENS analgesia, Referral of patients with refractory pain for procedures such as a nerve block, intrathecal analgesia, rhizotomy or orthopaedic stabilization.
c. Radiotherapy; Use of radiation to treat painful metastatic disease with single fractions, multiple fractions and hemi- body radiotherapy

ii. *Raised intracranial tension*: recognition, appropriate first response and cross referrals
iii. *Nausea and Vomiting:* Treatment of nausea and vomiting arising in advanced illness using anti-emetics, palliative management of sub-acute intestinal obstruction.
iv. *Anorexia and Dysphagia:* Management, where appropriate, with corticosteroids, progestogens and nasal gastric feeding
v. *Bowel obstruction:* Decompression with nasogastric tube, fluid and electrolyte balance, subcutaneous drug delivery and fluid management.
vi. *Pleural Effusions and Ascites:* Drainage of pleural effusions and ascites, other treatments such as pleurodesis / pigtail catheters etc.
vii. *Depression and Anxiety:* Knowledge regarding treatment of depression at all stages of cancer management, using counselling and drug techniques with anti-depressants; Knowledge regarding treatment of anxiety with counselling, anxiolytics and major tranquilisers.
viii. *Hospice Care Awareness of local hospice facilities:* A one week (at least) attachment to a hospice or palliative care team.
ix. *Counseling:* Counseling of patients and relatives at all stages of the disease

Investigational Techniques

i. *Laboratory Investigations*; Interpretation of the results of haematological, biochemical and radioimmunoassay investigations
ii. *Radiology*; Attendance at regular radiological review sessions involving a consultant clinical radiologist for the examination of plain x-rays, CT scans, magnetic resonance imaging and ultrasound covering the whole spectrum of cancer radiology, Current indications and techniques in interventional procedures.
iii. *Radiation Medicine Procedures*; Diagnostic Imaging – Gamma Camera, SPECT, PET Scanner, PET-CT and PET-MRI image fusion studies in treatment planning, response evaluation and follow up.
iv. *Pathology*; Attendance at regular pathological review sessions involving a consultant pathologist
v. *Genetics* in diagnosis, prognosis and treatment of cancer
vi. *Other Procedures*; Indirect laryngoscopy, Lumbar puncture, Skin biopsy, Fibre optic naso-endoscopy, Pelvic EUA and cystoscopy

Site or Disease Specific Procedures

Assessment, treatment and follow-up, in detail, for each of the anatomical sites and types of tumour, Presentation and assessment of patients discussed at multidisciplinary team meeting, Appropriate follow up, Acute and late side effects of treatment.

Clinical Trials, Literature and Research

The aims and format of Phase I to IV clinical trials, Obtaining informed consent, following study protocols and using data forms, Research programmes (although research experience is not a prerequisite), Major areas of current research and of recent important publications, Submission of a research project to an Ethics Committee, Structure and functioning of local and national clinical and research cancer networks. Ethics guidelines of research.

Communication and Publication

Effective communication with colleagues, patients and their carers; Giving clear and comprehensive descriptions of disease processes, investigations and treatment, Clear expression in English/local script and production of legible script, Preparing work for publication. Ethics of research publication

Outpatient and Joint Clinic

Participation in joint consultative clinics and regular general oncology outpatient sessions, Seeing review and new patients and planning their overall management.

Resource Management and Quality Assurance

Introduction to the resource management and quality assurance of an oncology service, so as to be able to develop these skills at a later stage

Prevention

A broad knowledge of the environmental causes of cancer and possible strategies for prevention. Knowledge about the Hospital based cancer registry and National Cancer Control Programme

Screening

Details of screening programs for cervical, breast, Head & Neck, Lungs, Prostate, GIT and other cancers which might form a major proportion of cancer cases in the country in the years to come.

Genetics

The familial aspect of some cancers as in colorectal, breast, ovary, retinoblastoma, multiple cancer syndromes etc and the management of high risk families and genetic counseling.

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Syllabus

Course contents:

Subjects for Part - I (First Year) Paper - I

Basic Sciences

1. **Applied Anatomy and Physiology**
   - A. Applied anatomy of oral cavity, larynx, pharynx, paranasal sinuses, CSF pathways salivary glands, middle ear, external orbit, breast, broncho- pulmonary segments, mediastinum, oesophagus, liver, spleen, stomach, small and large bowels, pelvic and genitor-urinary organs (bladder, uterus, ovary, testis rectum, anal canal etc.), spinal segments
   - B. Lymphatic system and lymphatic drainage pathway of various organs
   - C. Relationship of vital structures
   - D. Surface Anatomy pertaining to various organs
   - E. Cross Sectional Anatomy pertaining to US/CT/MR/PET images
   - F. General principles of physiology of respiratory, cardio-vascular, nervous, biliary, reproductive and endocrine systems and fluid-electrolyte-metabolic balance
2. **Various Investigative and Imaging Procedures** including radio-isotope based procedures in Diagnosis, Staging, Treatment Planning and follow up of cancer patients
3. **Pathology of Benign and Malignant Diseases**
   - A. Carcinogenesis - epidemiological studies, molecular studies, genetic basis, oncogenes, tumour growth kinetics
   - B. Pre-cancerous conditions
   - C. Methods of dissemination of cancer and its biological behaviour
   - D. Degree of differentiation of cancer
   - E. Principles and methods of definite diagnosis
     - i). Surgical biopsy - various procedures of biopsy
     - ii). Exfoliative cytology
     - iii). Fine Needle Aspiration Cytology (FNAC) and biopsy
     - iv). Tumour markers
   - F. General histologic and cytologic features of malignancy including features of special staining, surface markers, intracellular markers
   - G. Classification of benign and malignant tumours and their interpretation
   - H. Molecular pathology, molecular basis of diagnosis and prognosis of cancers
   - I. Radiation pathology
4. **Staging of various cancers:**
   - i. Evolution of different staging systems for various cancers over theyears.
   - ii. Clinical Staging, WHO Staging, TNM Staging, AJCC Staging and FIGO staging etc of various cancers, as applicable, with theirinter-comparisons.
5. **International Coding and classification of various neoplastic disorders**

   ICD-9, ICD-O and ICD-10 system of classification and coding of various tumours.

Paper II (Part I)

I. Radiation Physics

The following courses of study and the subjects are recommended for training in MD Radiotherapy and Oncology. It is essential that these topics be covered in detail for better understanding of the basics of radiation treatment, as per subject heads given below:

1. **Atomic and Nuclear Structure**
    - A. Atomic structure
        1. Energy levels, binding energy
        2. Transitions, characteristic radiations
    - B. Nuclear structure
        1. Mass, atomic and neutron numbers
        2. Nuclear binding energy
        3. Fission, fusion
        4. Nuclear reactors
2. **Radioactive Decay**
    - A. Modes of decay
        1. N/P ratio, even-odd relationship
        2. Beta decay
        3. Positron decay and electron capture
        4. Alpha decay
        5. Isomeric transitions, gamma emission, internal conversion
    - B. Mathematics of Radioactive Decay
        1. Units, half life, graphing
        2. Transient and secular equilibrium
        3. Radionuclide generators
    - C. Natural Radioactivity
        1. Naturally occurring isotopes
        2. Decay series
    - D. Artificial Radioactivity
        1. Production by neutron bombardment
        2. Fission products
        3. Production by charged particle bombardment
        4. Radioactivity equilibrium
3. **Production of X-rays**
    - A. X-ray tubes
        1. Requirements for X-ray production
        2. Historical development
        3. Focal spot size
        4. Reflection and transmission targets
        5. X-ray production efficiency
    - B. X ray circuits
        1. Primary circuits
        2. Secondary circuit
        3. Filament circuit
        4. Modes of rectification
4. **High Energy Treatment Machines**
    - A. Cobalt units
    - B. Van de graaff generators
    - C. Linear accelerators
    - D. Betatrons
    - E. Resonance transformers
    - F. Cyclotrons for neutrontherapy

G. Microtron, Synchrocyclotron and Particle Accelerators

5. Interactions of X – and Gamma-rays

A. Attenuation of a beam of x- or gamma-rays
   1. Attenuation and absorption coefficients
   2. Attenuation in the body

B. Modes of interaction
   1. Photoelectric absorption
   2. Compton scattering
   3. Pair production
   4. Photo-disintegration

6. Interactions of Particulate Radiations

A. Types of interactions
   1. Elastic, inelastic
   2. Excitation, ionization

B. Properties of particulate radiations
   1. Specific ionization
   2. LET

C. Interactions of heavy charged particles and pions
   1. Bragg's peak
   2. Applications in radiation therapy

D. Interactions of electrons
   1. Interactions with electrons
   2. Interactions with nuclei
   3. Applications to radiation therapy

E. Neutron interactions
   1. Slow neutron interactions
   2. Fast neutron interactions
   3. Applications with radiation therapy

F. Radioactive sources used in diagnosis and therapy - Production and properties

7. Measurement of Radiation Exposure

A. Photon and energy flux density and fluence
B. The roentgen
C. Electronic equilibrium
D. Ionization chambers
   1. Free-air chambers
   2. Thimble chambers
   3. Condenser chambers
   4. Electrometers
   5. Extrapolation chambers

E. Exposure calibration of an X - or gamma – ray beam
   1. Selection of calibration variables
   2. Selection of chamber
   3. Positioning of chamber
   4. Corrections to readings

F. Quality assurance checks on radiation therapy units

8. Radiation Quality

A. Measures of quality
   1. HVL and effective energy

B. Factors influencing quality

1. Variations in quality across abeam
2. Filtration an acceleration potential

9. Measurement of Absorbed Dose

A. Units of radiation dose, dose equivalent, RBE-dose
B. Calculation of dose from exposure
C. Measurement of absorbed dose with an ionization chamber
   1. Bragg-Gray cavity theory
D. Direct measurement of absorbed dose
   1. Film
   2. TLD
   3. Calorimetry
   4. Chemical dosimetry

10. Calibration of High Energy Photon and Electron Beams

A. Photons
   1. Stopping power ratios and energy absorption coefficients
   2. Acq
   3. C
B. Electrons
   1. C_E

11. Dose Distribution, External Beam Therapy

A. Dosimetric variables
   1. Back scatter factor
   2. Percent depth dose
   3. Tissue – air ratio
   4. Scatter – air ratio
   5. Tissue - maximum and tissue-phantom ratios
   6. Isodose distributions
   7. Treatment time calculations
   8. Fixed SSD and isocentric treatment techniques
   9. Beam Modulation
B. Single and multiple field dose distributions
   1. Corrections for wedges
   2. Design for compensating filters
   3. Corrections for surface obliquities
   4. Corrections for heterogeneities
   5. Dose perturbations at interfaces
   6. Adjoining fields
   7. Integral dose
C. Dose distribution for rotational therapy
D. Calculation of dose in large, irregular fields

12. Dose Distribution, Sealed Source Therapy

A. Handling of sealed radioactive sources
B. Dose distributions for sealed implant sources
C. Design of sealed source implants
D. Radium and its substitutes
E. Special techniques for ^{192}Ir and ^{125}Ir
F. Other sealed sources in therapy

13. Computerized Treatment Planning

A. External X-and gamma-ray beams
   1. Rectangular fields

2. Irregular fields
3. Inverse Planning

B. Electron beams

C. Implanted sources
1. Intracavitary sources
2. Interstitial implants
3. Surface mould

14. Radiation Protection from External Sources

A. Concepts and units
1. Quality factors
2. Dose equivalent
3. Protection regulations

B. Treatment room design
1. Primary radiation
2. Scatter
3. Leakage
4. Special problems with high energy photon and electron beam
5. Special problems with neutron, proton and π-meson

C. Sealed source storage

D. Protection surveys

E. Personnel monitoring

15. Radiation Protection from Internal Sources

A. Body burdens and critical organs
1. Effective half lives for uptake and elimination.

B. Internal dose computations
1. Locally absorbed radiation
2. Penetrating radiation

C. Handling radionuclide therapy patients

D. Licensing procedure for using radionuclides

16. Planning of a Radiotherapy Department

A. Building designs

B. Choice of various equipments and sources

C. Acceptance and Calibration Tests

D. Various maintenance steps and procedures

17. New Radiation Modalities:

A. Protons
1. Production
2. Processes of absorption
3. Depth dose patterns
4. Advantage compared with x-rays
5. Facilities available

B. Neutrons
1. Production
2. Processes of absorption
3. Depth dose patterns
4. Advantages compared with x-rays
5. Facilities available

C. Pions
1. Production
2. Processes of absorption

3. Depth dose patterns
4. Advantages compared with x-rays
5. Facilities available

D. High energy heavy ions
1. Production
2. Processes of absorption
3. Depth Dose Patterns
4. Advantages compared with x-rays
5. Facilities available

II. Radiobiology (Radiobiology and Laboratory Radiotherapy)

1. Mammalian Cell Radiosensitivity

A. Apoptosis, Interphase and reproductive death
B. Cell survival curves in vitro
C. Characterization of cell survival curves
D. Critical sites and target theory
1. DNA
2. Membranes
E. Dose response curves invivo
1. Skin clone
2. Surviving crypts
3. Bone marrow colonies growing in spleen, mono layer culture
F. Quantitative normal tissue reaction based on systems
1. Pigskin
2. Rodent skin
3. Lung
4. Esophagus
5. Kidney
6. CNS and spinal cord

2. Factors that Modify Radiation Response

A. The Oxygen effect
1. Effect of oxygen concentration
2. Time of action of oxygen
3. Mechanism of the oxygen effect
4. Implications for radiotherapy
5. Methods to overcome problems of hypoxic cells
B. The age response function
1. The cell cycle
2. Age response for cells cultured in vitro
3. Age response for tissues in vivo
4. Age response for neutrons
5. The oxygen effect through the cell cycle
6. Implications for radiotherapy
C. Potentially Lethal damage
1. Repair *invitro*
2. Repair *invivo*
3. PLD and high LET radiations
4. Implications in radiotherapy

D. Sublethal damage
   1. Split-dose experiments with cell in vitro
   2. Sublethal damage repair in normal tissues
   3. Sublethal damage repair in tumours
   4. Sublethal damage and hypoxia
   5. Sublethal damage and high LET radiations
   6. Dq as a measure of repair

E. Dose-rate
   1. Dose-rate effects in cells *in vitro*
   2. Dose-rate effect in normal tissues
   3. Dose-rate effect in tumours
   4. Interstitial therapy
   5. Beam therapy at low dose rate

F. Radiosensitizers
   1. The halogenated pyrimidines
   2. Hypoxic cell radio sensitizers
      a. Structure and mode of action
      b. Enhancement ratio
      c. Metronidazole / misonidazole
      d. Pharmacokinetics in the human
      e. Clinical limitations
   3. Antibiotics

G. Radioprotectors
   1. Free radical scavengers

3. Linear Energy Transfer
   A. Definition
   B. Track and energy average
   C. LET for different types of radiation
   D. OER as a function of LET

4. Relative Biological Effectiveness (RBE)
   A. Definition
   B. RBE for different cells and tissues
   C. RBE as a function of dose
   D. RBE and fractionation
   E. RBE as a function of LET
   F. Q factor

5. Cell and Tissue Kinetics
   A. The cell cycle
   B. Autoradiography
   C. Constituent parts of the cell cycle
   D. Percent labeled mitoses technique
   E. Growth fraction
   F. Cell loss factor
   G. Growth kinetics of human tumours

6. Tissue Radio sensitivity
   A. Classification based on radiation pathology
   B. Types of cell populations
      1. Self renewal
      2. Conditional renewal
      3. Stem cell

4. Differentiated

7. Time-Dose and Fractionations

A. The 4 R's of radiobiology
B. The basis of fractionation
C. The Strandquist's plot
D. Nominal standard dose
E. Linear Quadratic equation

8. Hyperthermia

A. Methods of heating
B. RF microwaves
   1. Ultrasound
   2. Water baths
C. Systematic hyperthermia
D. Localized heating
E. Cellular response to heat
F. Repair of thermal damage
G. Thermo tolerance
H. Hyperthermia combined with ionizing radiations
I. Time sequence of heat and irradiation
J. Hypoxic cells and heat
K. Effect of pH on the response to hyperthermia
L. Response of transplanted tumours to heat
M. Response of spontaneous tumours to heat
N. Response of normal tissues to heat
O. Heat and the therapeutic gain factor
P. Hyperthermia and chemotherapy

9. Total Body Irradiation – Acute Effects

A. Prodromal radiation syndrome
B. Central nervous system / cerebro-vascular syndrome
C. Gastrointestinal syndrome
D. Haematopoietic syndrome
E. Mean lethal dose:(LD_{50})
F. Treatment of radiation accident

10. Late Effects

A. Probabilistic/Deterministic (Stochastic/Non-Stochastic)effects
B. Non-specific life shortening
   1. Definition
   2. In animals
   3. In man
C. Carcinogenesis
   1. The latent period
   2. Dose response curve in animals
   3. Leukemia
   4. Breast cancer
   5. Thyroid cancer
   6. Bone cancer
   7. Skin cancer
   8. Lung cancer
   9. Other tumours
   10. Malignancies in prenatally exposed children

11. Mechanisms of Radiation Carcinogenesis

A. Genetics of irradiation
   1. Point mutations
   2. Relationship to dose
   3. Chromosome aberrations
   4. Relationship to dose
   5. Doubling dose
   6. Genetically significant dose(GSD)
   7. Genetic effect in humans
   8. Background radiation in relation to the GSD

12. Radiation Effects in the Developing Embryo and Fetus

A. Intrauterine death
B. Congenital abnormalities including neonatal death
C. Growth retardation
D. Dependence of the above effects on dose, dose-rate and stage ingestation
E. Carcinogenesis following *in utero* exposure
F. Human experience of pregnant women exposed to therapeutic doses
G. Occupational exposure of potentially pregnant women
H. Elective booking or "10 day rule"
I. The "Practical threshold" for therapeutic abortion

III. Radiation Pathology:

1. Radio-physiology of Human Tissues

A. Effects or irradiation of the skin
   1. Clinical manifestations
   2. Histological substratum of effects
   3. Repair
   4. Degree of sequelae
   5. Injurious effects

B. Effects of irradiation of bone and cartilage
   1. Effects on growing bones and cartilage
   2. Effects on adult bones and cartilage
   3. Clinical manifestations
   4. Histological substratum of effects
   5. Functional consequences and sequelae

C. Effects of irradiation of the kidney
   1. Clinical manifestations
   2. Histological substratum of effects
   3. Acute and chronic functional repercussions
   4. Permanent Sequelae

D. Effects of irradiation of the lung
   1. Acute clinical effects
   2. Ultimate effects
   3. Histologic substratum of effects
   4. Measures to reduce final effects
   5. Sequelae

E. Effects of irradiation of nervoustissues
   1. Effects on the brain
   2. Effects on the spinal cord
   3. Effects on the peripheral nerves
   4. Clinical manifestations

5. Histological substratum
6. Sequelae

F. Effects of irradiation of the ovary
1. Clinical manifestations
2. Histological substratum
3. Reversibility of effects
4. Therapeutic implications

G. Effects of irradiation of the testis
1. Clinical consequences
2. Histological substratum
3. Reversibility
4. Protective measures

H. Effects of irradiation of the eye
1. Clinicalconsequences
2. Histologicalsubstratum
3. Protectivemeasures
4. Time-dose connotations
5. Sequelae-therapy

I. Effects of irradiation of lymphoidtissues
1. Clinical manifestations
2. Histological manifestations
3. Reversibility

J. Effects of irradiation of the bone marrow
1. Clinical and laboratory manifestations
2. Chronology of effects
3. Histologic substrarum
4. Recovery
5. Therapeutic applications

K. Effects or irradiation of the oral, pharyngo-laryngeal and esophageal mucous membrane
1. Clinical manifestations
2. Histological manifestations
3. Repair
4. Sequelae

L. Effects of irradiation of the salivary glands
1. Acute manifestations
2. Histological substratum
3. Dental consequences
4. Prophylaxis

M. Radiation effects observable in clinical radiotherapy
1. Technological protection
2. Role of total dose
3. Role of fractionation
4. Measures of prevention
5. Therapeutic measures

N. Effects of irradiation of human embryo
1. Role of age
2. Role of dose
3. Teratogenic effects
4. Measures of prevention

O. SOMA Scales

IV. Basics of Chemotherapy:

A. Classification, mechanisms of action and pharmacokinetics of anti-cancer (cytotoxic) drugs including - Platinum analogues ; Antimetabolites ; Alkylating agents ; Anthracyclines ; Topoisomerase interactive agents ; Microtubule interacting agents ; Kinase inhibitors ; Histone deacetylase inhibitors ; Proteasome inhibitors ; PARP inhibitors ; Antiangiogenic agents ; Targeted therapies ; Hormonal agents – SERMs, GnRH analogues, AIs, anti-androgens ; Monoclonal antibodies, and other forms of immunotherapy ; Misc. drugs & Biological Response Modifiers

B. Rationality of using cytotoxic drugs as single agents and as multi-drug protocol in various clinical settings

C. Dosages/Modes/routes of administration of cytotoxic drugs

D. Complications/adverse effects of various cytotoxic drugs

PART – II

Paper I

Principles of Radiotherapy allied specialties

I. Clinical Practice of Radiotherapy and Oncology

A. Principles of Radiotherapy

1. General – Radiosensitivity and Radiocurability
   - Tumor lethal dose, Tissue Tolerance and Therapeutic Ratio (TR)
   - Factor influencing TR
   - Target Volume
   - Choice of Time, dose fractionation and technique

2. Teletherapy
   Radiation factors
   Megavoltage therapy
   Orthovoltage therapy
   Electron therapy
   Heavy particle therapy (Neutron, photon, pi-meson)
   Proton Therapy

3. Brachytherapy
   Radium and its substitutes
   Practice of - surface, intracavitary and interstitial Clinical application
   Rules and techniques
   1. Newer developments
   2. Afterloading
   3. Low and high dose rates

B. Techniques of Radiotherapy
   Small field beam directed therapy
   Extended and irregular field therapy Single, double and multiple field therapy
   Beam modification therapy (wedge filter / compensator etc.)
   Rotation and Arc therapy
   IMRT, IGRT, Tomotherapy
   Newer Techniques

Techniques in brachytherapy,
intracavitary Interstitial
Mould application

Modern development and afterloading devices

C. Clinical Practice
Radical (curative)
Palliative
Pre-operative
Post-operative
Supplementary
Combination (both Pre- & Post operative – Sandwitch technique) Nutritional care and local hygiene during and after therapy

D. Treatment Planning and Presentation
Mould room practices
Simulation
Computerised treatment planning system
Clinical dosimetry
Prescription and execution

E. General histologic and cytologic features of malignancy

F. Classification of benign and malignant tumours and their interpretation

II. Related Specialties: surgical oncology and medical oncology

A. Principles and practice of general surgery, gynecology and pediatric surgery as related to cancer
Surgical treatment decisions
Surgical diagnosis and staging of cancer

B. Cancer Chemotherapy and Hormones

Chemotherapy

Principles and clinical practice Classification of drugs
Clinical application of
a. Single drug therapy
b. Polychemotherapy and various combinations
c. Adjuvant therapy
d. Prophylactic therapy
Complication of the chemotherapy and its management
Recent developments
Drug schedules

Hormone Treatment in Cancer

General principles
Role in cancers of the Breast, thyroid, prostate, kidney etc.
Complications and their management

C. Clinical staging and TNM system
Staging procedures
Methods of clinical staging and TNM classification

D. Terminal care of cancer patients – principles and practice of control of pain

E. Cancer registry and epidemiology

F. Prevention and early detection in cancer

G. Cancer education and oncology organization

H. Statistical methods

Papers II & III

A. Clinical Management in tumors of:

a. Head and Neck

- Lip

- Oralcavity
- Oropharynx
- Hypopharynx
- Nasopharynx
- Supraglottis
- Vocal cord
- Sub-glottis
- Middle ear
- Nose and nasalsinuses
- Orbit and opticnerve
- Lachrymal gland
- Salivary gland
- Glomus jugulare tumours
- Carotid body tumours
- Other sites in the region

b. Gastro-IntestinalTract

- Oesophagus
- Stomach
- Liver
- Pancreas and biliary tract
- Small bowel
- Colon and rectum
- Anal canal and peri-anal region

c. Chest

- Pleura
- Trachea
- Lung
- Mediastinum and thymus

d. Genito-Urinary Tract

- Kidney
- Ureter
- Bladder
- Urethra
- Prostate
- Penis
- Testis

e. Female GenitalTract

- Uterine cervix
- Uterine body
- Vagina
- Vulva
- Ovary
- Fallopiantube

f. Central NervousSystem

- Brain
- Spinalcord
- Craniopharyngioma
- Chordoma
- Acoustic neuroma
- Meninges

g. Soft Tissue Sarcomata and Bone Tumours

- Adult soft tissues arcoma
- Childhood/adolescent sarcoma
- Chondrosarcoma
- Osteosarcoma
- Ewing's tumour

h. Paediatric Tumours

- Medulloblastoma
- Neuroblastoma
- Nephroblastoma
- Retinoblastoma
- Embryonal sarcomas

i. Lymphoproliferative and Myeloproliferative Disorders

- Hodgkin's lymphoma
- Non-Hodgkin's lymphomas
- Plasma cell malignancies
- Acute and chronic leukaemias

j. Skin

- Basal cell carcinoma
- Squamous cell carcinoma
- Malignant melanoma
- Cutaneous lymphoma
- Kaposi's sarcoma

k. Endocrine

- Breast
- Thyroid
- Parathyroid
- Pituitary
- Adrenal

l. Other tumours and tumour- like conditions

m. Metastatic cancer in unknown primary

B. For each of the tumour types and sites listed above, the post graduate students shall learn the:

a. Management

- Initial staging investigations including imaging and tumour markers

- Role of PET-CT in modern day management of cancers
- Relevant prognostic factors
- Assessment for treatment
- Role of surgery
- A management plan, or, where applicable, a range of such plans
- Ionising Radiation Regulations
- Roles of surgery, radiotherapy and cytotoxic chemotherapy in multimodality approaches to cancer treatment

b. Pathology

- The range of tumours that can occur
- Their aetiology, incidence and epidemiology
- A brief morphology of the common tumours
- The natural history of the disease including likely presentation, characteristic growth and metastatic pattern
- Staging classifications eg TNM, WHO, FIGO, AJCC,AFIP
- Use of tumour markers in diagnosis and treatment of tumours
- Use of specialized pathology techniques, eg immuno-cytochemistry
- Interpretation of clinic pathological data in the tumour site specialised multidisciplinary approach to patient management

c. Radiotherapy

i. The role of irradiation in radical and palliative management
ii. Where radical radiotherapy is a treatment option:
    1. Staging investigations
    2. A definition of tumour volume and target volume boundaries
    3. ICRU, AAPM, ICRP reports relevant to clinical oncology
    4. An acceptable radio therapeutic technique, or, where applicable, a range of such techniques
    5. The correct treatment position
    6. Details of the target volume localization process
    7. Use of CT axial images, 3D planning, Inverse Planning, IMRT, IGRT, Irregular shaped fields
    8. Verification techniques such as laser alignment, skin tattoos, orthogonal and portal films
    9. The approximate dose distributions for the chosen technique
    10. An appropriate dose/fractionation regime
    11. Relevant dose modifying factors (changes in fractionation, age, associated conditions, target volume, intercurrent infections, previous therapies)
    12. Details of the set-up instructions for technologists
    13. Appropriate responses to changes of patient parameters or interruptions during treatment
    14. The possible acute and late side effects of their radiation
    15. Radiation dose modifying factors, chemotherapy timing in all forms of chemo-radiation schedules

d. Drug Therapy: Basic knowledge and understanding of integrating with Radiotherapy

i. The role of cytotoxic, hormonal and biological drugs therapies in radical and palliative management

e. Outcomes

i. The expected outcomes of treatment

ii). Biological Therapies

i. A basic knowledge of the clinical uses of currently used biological therapies including interferons, colony stimulating factors, interleukins, erythropoietin, other growth factors and preparations such as imatinib, geftinib, nimotuzumab, trastuzumab, rituximab, erlotonibetc.

f. **Oncological Emergencies**

- The management of the following complications when they are related to cancer:
  - Ureteric obstruction
  - Spinal cord compression
  - Haemorrhage
  - Mediastinal superior vena caval obstruction

C. Radiotherapy for Benign Disease

- The indications for radiotherapy in the treatment of benign conditions, including suitable techniques and dosage schedules, and likely benefits and risks

D. Complications of Treatment

- The acute and late complications of oncological treatment and their management including:
  - Skin reactions
  - Nausea and vomiting
  - Diarrhoea
  - Oedema
  - Bone marrow toxicity
  - Neutropenic sepsis
  - Drug reactions
  - Cytotoxic extravasation
  - Alopecia
  - Cataract
  - Skin atrophy and ulceration
  - Colitis, proctitis, gut strictures and perforation
  - Renal effects
  - Cardiac effects
  - Pulmonary effects
  - Fibrosis and lymphoedema
  - Endocrine effects (thyroid, pituitary and salivarygland)
  - Effects on fertility
  - Incidence of second and radiation induced cancers

E. Symptom Control and Continuing Care

- The available medical and surgical techniques for the control of pain, nausea, vomiting and malignant effusions

- Treatment of various cancer related conditions and paraneoplastic syndromes including
  - Hypercalcaemia
  - Ectopic hormone production
  - Raised intra cranial pressure
  - Anaemia

F. Current Research and Literature

- Current major research in progress in the form of multi centric trials
- Recent major publications in oncology journals
- Understanding evidence based medicine and how to read literature

Part IV:

Recent Advances and Special Topics

Special Topics

A. Recent advances coming up in various fields as applicable to oncology
B. Stereotactic body radiotherapy and stereotactic surgery
C. Causes of treatment failure and retreatment including reirradiation
D. Motion management strategies in radiation treatment including deep inspiratory breath hold, abdominal compression
E. TLI and TBI – Role, Philosophy and Techniques
F. Supportive care in Radiation treatment in combination with chemotherapy/surgery
G. Infections, nutritional and other problems in cancer patients
H. Preventive Oncology
I. Psychosocial aspects of cancer and Rehabilitation
J. Hospice Program
K. Immunotherapy and Role of Monoclonal antibodies in diagnosis, staging and management of cancer
L. Oncological Emergencies
M. Care and Nursing of patients on Radiotherapy and Chemotherapy
N. Cancer Control Programmes
O. International Classification and Coding of Cancer (ICD-9, ICD-O, ICD-10)
P. Research Methodologies in Cancer
Q. Use of Artificial Intelligence in management of cancer

This being a highly dedicated PG specialty introducing several new concepts/subjects in the course, it is recommended to divide the entire course into two components consisting of First Year of Basic Concepts Of The Specialty and the next two years of Intensive Clinical Training In The Specialty.

The subjects recommended to be covered during the first year are:

- Basic Sciences including concepts of carcinogenesis & epidemiology of cancer
- Applied anatomy and physiology
- General pathology and pathology of tumours
- Medical physics related to Radiotherapy

- Radiobiology
- Radiation Pathology
- Classification, mechanisms of action and Pharmacokinetics of anti-cancer (cytotoxic)drugs
- Rationality of using cytotoxic drugs as single agents and as multi-drug protocol in various clinical settings
- Imaging techniques
- Staging of cancers of various sites.

The post graduate students should devote **next two years** in learning the science and art of practice of Oncology focusing upon radiotherapy along with knowledge of integration of other modalities in total management of cancer, as elaborated in the subsequent sections.