Radiation Therapy Professional Curriculum

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Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3917.

Radiation Therapy Professional Curriculum *was produced by the ASRT Task Force on Educational Standards in Radiation Therapy.*

Contents

Introduction

Today's radiation therapists are providers of direct patient care services who demonstrate critical thinking skills and independent decision making based on a solid foundation in theory and practice through mastery and understanding of the psychology and humanness of those they serve — their patients.

This baccalaureate professional curriculum and supplemental documents establish the foundation of the radiation therapy profession. When delivered by qualified, competent faculty, the curriculum objectives are:

- To infuse students with a solid foundation of radiation therapy and practice.
- To develop critical thinking skills essential to decision making in clinical practice.
- To establish as life-long values the importance of continuing professional education, dedication to the patient and service to society.

This professional curriculum is a product of six years of hard work. In 1990, leaders of the American Society of Radiologic Technologists named a task force of member volunteers to research, develop and validate the various elements that comprise a professional entry-level baccalaureate curriculum. Known as the Task Force on Educational Standards in Radiation Therapy, these 12 individuals contributed significantly to the process during their terms of service. Assisted by hundreds of radiation therapists throughout the professional community who provided reviews, suggestions, critiques and comments, the task force completed its charge, providing a new foundation for the practice of radiation therapy in the 21st century. ASRT gratefully acknowledges their contribution.

Task Force on Educational Standards in Radiation Therapy

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Curriculum Elements

The professional baccalaureate curriculum design should follow an educational plan that fully documents each essential element. The design should be based on a broad foundation of liberal arts, sciences and professional education that minimally includes liberal arts, sciences, professional practice, research, administration/management and clinical practice learning.

Liberal Arts
Liberal arts content may be prerequisite to or concurrent with professional education content.

Liberal arts content must:

- Facilitate the sequential development of oral and written communication skills.
- Facilitate and enhance critical thinking, analysis and problem-solving skills and creativity.
- Demonstrate evidence of broadening knowledge and appreciation of a global multi-cultural society.
- Facilitate the ability to make judgments in the context of historical, social, scientific, political and economic information.

Sciences
Sciences content may be prerequisite to or concurrent with professional education content.

Biological sciences content must encompass structure and function of the human body including anatomy, physiology and pathology of normal and abnormal conditions across the life span.

Behavioral sciences content must encompass sociocultural systems to include beliefs, ethics and values. Human development inclusive of cognitive, psychosocial and physiological components should be evident.

Physical sciences content must encompass mathematics, statistics, computers, chemistry, physics, radiation physics and radiation biology.

Health sciences must encompass concepts of the U.S. health care delivery system, public policy and regulatory agencies, health care finance, health education and health administration. Focus on interdisciplinary cognate areas must be evident.

Professional Practice
Professional practice content must:

- Encompass radiation therapy theory and clinical practice.
- Include foundations, history and philosophical base of the profession and its practitioners.
- Encompass didactic and clinical components reflective of contemporary practice in radiation therapy.

Research

Research content must:

- Encompass the need for and value of applied and basic research for clinical practice and professional development of radiation therapists.
- Encompass specific elements of the research process and a research protocol.
- Result in the ability to interpret studies related to radiation therapy and apply research results to radiation therapy delivery system services.

Administration/Management

Administration/management content must:

- Encompass theory and application of principles in the delivery of radiation therapy services to individuals within organizational settings.
- Encompass technology in radiation therapy treatment delivery systems using service delivery models that include the private and public affiliated or nonaffiliated sectors in health care.
- Encompass applicable federal and state law and regulations, radiation safety standards, credentialing and accreditation requirements.

Clinical Practice Learning

The clinical learning content may be integrated each year or in a combination of years in the curriculum or may be structured as an intensive year-long post-didactic learning experience, such as field work or internship.

Clinical learning content must:

- Encompass delivery of comprehensive radiation therapy services to cure or improve the quality of life in patients by accurately delivering a prescribed course of treatment adhering to acceptable departmental, institutional, governmental and professional standards, policies and procedures.
- Encompass assessment and evaluation of processes and outcomes.
- Encompass the daily assessment and evaluation of the patient's physiological and psychological preparedness for treatment delivery.
- Differentiate essential members of the health care team and their contribution in provision of multidisciplinary patient care.
- Encompass strategies that assure professional development at a level of clinical practice consistent with acceptable standards.

Orientation to Radiation Therapy

Course Description

Content will provide student with an overview of the foundations in radiation therapy and the practitioner's role in the health care delivery system. Principles, practices and policies of the educational program, health care organizations, principles of radiation and health safety and professional responsibilities of the radiation therapist will be discussed and examined.

Course Objectives

At the completion of the content outline, the student must:

1. State the policies of the educational program regarding class attendance, grading, vacation/sick leave, progressive discipline, appeals, pregnancy and communicable disease procedures.
2. Discuss the policies of clinical education center(s) that affect students.
3. List the major responsibilities of a radiation therapy student.
4. Identify other health science professions that participate in the patient's total heath care.
5. Describe the relationship of health care providers in the integrated care of cancer patients.
6. Discuss the philosophy and mission of the hospital/clinical education center(s).
7. Identify key administrative personnel and discuss their relationship to the radiation therapy student.
8. Describe relationships and interdependencies of departments within the hospital/clinical education center.
9. Identify and discuss the responsibilities and relationships of all personnel in the radiation therapy department.
10. Identify basic radiation safety procedures for personnel and patients.
11. State the procedures for monitoring radiation occupational individuals.
12. Define and discuss key terms in radiation therapy.
13. Identify the contents/sections of the patient's chart.
14. Recognize and adhere to the responsibility of patient, staff and facility confidentiality.
15. Identify basic health safety procedures for personnel and patients.
16. Define accreditation, credential, certification, licensure and regulations.
17. Explain the difference between the accreditation and credentialing processes and identify agencies involved in each process.
18. Describe how the Joint Review Committee on Education in the Radiologic Technology (JRCERT) Standards for an Accredited Educational Program in the Radiologic Sciences relate to the educational program.
19. Explain how regional accrediting bodies relate to the educational program.
20. Describe purposes, functions and activities of professional organizations.
21. Identify international, national, state and local organizations for the radiation therapist.
22. Recognize the importance of professional commitment and involvement.
23. Discuss the general employment outlook and economic return for the graduate.

24. Discuss career advancement and opportunities for the radiation therapist.
25. Identify the benefits of continuing education as related to improved patient care and professional and personal enhancement.

Course Content

I. Policies and Procedures of the Educational Program

A. Program officials
   1. Director
   2. Clinical supervisors/clinical coordinators
   3. Medical director/advisor
   4. Clinical instructors
   5. Others

B. Educational program information
   1. Curriculum/master plan
   2. Course registration
   3. Tuition and fee policies
   4. Student insurance
   5. Textbooks
   6. Graduation requirements/terminal objectives
   7. Educational schedule
      a. Didactic
      b. Clinical
   8. Attendance
   9. Dress code
   10. Grading policy
   11. Vacation/sick leave policy
   12. Progressive discipline policy
   13. Appeals procedure

C. Clinical education center(s)
   1. Operations schedule
   2. Conference schedule
   3. Clinical hours
   4. Equipment
   5. Record keeping
   6. Dress code
   7. Security measures
   8. Parking regulations
   9. Emergencies/incident reporting
   10. Supervision
   11. Clinical evaluation
   12. Confidentiality

D. Responsibilities of students
   1. Didactic
      a. Attendance
      b. Class participation
      c. Assignments
      d. Examinations
   2. Laboratories
      a. Attendance
      b. Assignments
      c. Evaluation
   3. Clinical
      a. Attendance
      b. Assignments
      c. General patient care
      d. Radiation treatment delivery
      e. Simulation procedures
      f. Medical dosimetry
      g. Evaluation

II. The Health Science Professions

A. Radiologic sciences
   1. Radiography
   2. Radiation therapy
   3. Nuclear medicine
   4. Diagnostic medical sonography
   5. Magnetic resonance
   6. Computerized tomography
   7. Mammography

B. Other health care groups
   1. Dietetics
   2. Health information
   3. Medical laboratory sciences
   4. Occupational therapy
   5. Pharmacy
   6. Physical therapy
   7. Respiratory therapy
   8. Social services
   9. Nursing
   10. Other

III. Hospital Organization

A. Administrative services
   1. Governing board
   2. Hospital/clinical education center administration
   3. Admissions
   4. Information systems
   5. Procurement
   6. Accounting
   7. Housekeeping
   8. Laundry
   9. Security
   10. Personnel

B. Medical services
   1. Medical director
   2. Medical staff
   3. Resident staff
   4. Intern staff
   5. Medical students
   6. Nursing service
   7. Clinical services

C. Ancillary services
   1. Clinical services
   2. Medical laboratories
   3. Rehabilitation
   4. Radiology
   5. Pharmacy
   6. Social services
   7. Dietary
   8. Dental
   9. Pastoral care

D. Radiation therapy services organization
   1. Professional personnel
      a. Director/chairman
      b. Radiation oncologists
         1) Attending
         2) Resident
         3) Intern
      c. Radiation physicist
         1) Staff physicist
         2) Research assistant

d. Radiobiologist
    1) Staff biologist
    2) Research assistant
e. Radiation therapist
    1) Administrative director
    2) Chief/senior radiation therapist/lead radiation therapist
    3) Staff radiation therapist
    4) Treatment planning radiation therapist
    5) Educational director
        a) didactic instructor
        b) clinical instructor
        c) student therapist
    6) Cast and mold room staff
    7) Radiation therapist assistants
f. Medical dosimetrist
g. Nurses
    1) Head nurse
    2) Staff nurse
h. Social worker
i. Nutritionist
j. Others

2. Support personnel
    a. Clerical staff
        1) Administrative assistant
        2) Receptionist
        3) Medical secretary
    b. Accounting
        1) Billing
        2) Purchasing
    c. Cancer registry
    d. Transportation services
    e. Medical records
    f. Others

IV. Introduction to Radiation Therapy

A. Cancer management
    1. Cancer incidence
    2. Epidemiology and etiological studies
    3. Detection and diagnosis
    4. Prevention
    5. Treatment
        a. Radiation oncology
        b. Surgical oncology

c. Medical oncology
d. Immunotherapy
e. Alternative

B. Radiation therapy treatment techniques
1. External
2. Brachytherapy
a. Interstitial
b. Intracavitary
3. Systemic
4. Contact
5. Intraoperative
6. Stereotactic
7. Hyperthermia

C. Key terms
1. Tumor dose
2. Maximum dose (D_{max})
3. Depth
4. Cumulative dose
5. Collimators
6. Gantry/gantry angle
7. Back-up timer
8. Monitor unit/time
9. Wedge

D. Patient record/chart
1. Contents
2. Daily treatment record
3. Confidentiality

E. Treatment protocols

F. Radiation safety
1. Monitoring
2. Protection
a. Personnel
b. Patient
c. Public

G. Health safety
1. Prevention of disease spread
a. Hand washing

b. Equipment cleaning
c. Universal precautions

V. Professional Credentialing and Accreditation

A. Definition
1. Credentialing
2. Accreditation

B. Organizations
1. Agencies
a. American Registry of Radiologic Technologists (ARRT)
1) Function
2) Structure
3) Individual credentialing
b. Joint Review Committee on Education in Radiologic Technology (JRCERT)
1) Function
2) Structure
3) Essentials
4) Program accreditation
c. Regional accrediting bodies

C. Federal and state agencies
1. Licensure
2. Regulations

VI. Professional Development

A. Methods of advancement
1. Continuing education programs
2. Collegiate programs
3. Geographical mobility
4. Economic considerations
5. Human resources issues

B. Clinical
1. Administration
2. Medical dosimetry/treatment planning
3. Physics
4. Research
5. Hyperthermia

C. Industrial
1. Commercial
2. Governmental

D. Education
    1. Administration
    2. Clinical
    3. Higher education

E. Continuing education/competency requirements
    1. Definition
    2. Rationale
    3. Requirements
    4. Opportunities

Ethics in the Radiologic Sciences

Course Description
Content is designed to establish a foundation and parameters of professional practice for radiation therapists. Ethical behaviors as providers within a defined scope of practice will be discussed and examined within the context of the health care delivery system.

Course Objectives
At the completion of the content outline, the student must:

1. Judge the clinical significance of patients' personal beliefs and values as they affect the ability to adapt to the treatment plan.
2. Demonstrate awareness of and operate within the scope of practice, regardless of personal beliefs and the appropriateness of the patient's decision.
3. Identify and appreciate standards of behavior in health care as a continuum, with historical and philosophical foundations in human history.
4. Discuss ethics as a branch of philosophy and the moral, social and cultural basis of the development of an ethic.
5. Differentiate between empathetic rapport and sympathetic involvement in relationships with patients relative to ethical conduct.
6. Compare and contrast the evolution of the major health care professions and their codes of ethics.
7. Appreciate professional ethics in the context of a broader societal ethic.
8. Identify and discuss ethical dilemmas confronting health care professionals in providing care to cancer patients and their families.
9. Identify and rationalize concepts of personal honesty, integrity, accountability, professional competence and compassion as ethical imperatives in professional practice.
10. Identify, discuss and employ a basic system of examination, clarification, determination of alternatives and decision making in ethical questions.
11. Identify, discuss and define the concepts embodied in principles of patient rights, the doctrine of informed consent and other issues related to patient rights.
12. Given examples, compare and contrast ethical and legal responsibilities of the radiation therapist.

Course Content

I. Historical and Philosophical Context

A. Origins of the healing arts

B. Healing, healers, magic, religion

C. Principles, duties and virtues of a healer

D. Milestones in the history of medical ethics

E. Holistic considerations

II. Ethics, a Branch of Philosophy

A. The "examined" life, reflection, motivation

B. Search for ideal behavior

C. Professional ethics

D. Classical philosophy

E. Medieval philosophy

F. Contemporary philosophy

G. Relationship of personal, cultural, societal and professional ethical systems

H. Ethical behavior in health care

I. Components of professional code of conduct
   1. Scope of practice
   2. Confidentiality
   3. Respect for profession
   4. Personal behavior imperatives

III. Elements of Ethical Behavior

A. Moral reasoning

B. Personal behavior standards

C. Competence

D. Compassion, empathy, sympathy

E. Honesty, integrity, accountability

F. Scope of practice defined
   1. Lines of authority
   2. Areas of responsibility
   3. Limitations
   4. Orders, prescriptions

G. Self-assessment and self-governance

H. Continuing professional education

I. Professional standards
   1. Education
   2. Accreditation
   3. Registration, certification, licensure
   4. Radiation Therapy Scope of Practice
   5. Radiation Therapy Standards of Care

J. Code of professional ethics

IV. Ethical Issues and Dilemmas in Health Care

A. Individual and societal rights

B. Autonomy vs. behavior control

C. Access and distribution of health care
   1. Justice
   2. Fairness
   3. Economics

D. Financing health care—who pays?

E. Access to good health, health care and technology

F. Human experimentation: risks, rights and volunteers—implications for students and practitioners

G. Medical/health care research

H. Decisions of the terminally ill: living wills, advanced directives, non-intervention, health care proxy

I. Analyzing ethical problems: goal theories, rights theories, duty theories

J. Ethical decision making: weighing data, alternatives, risks vs. benefits

Introductory Law in the Radiologic Sciences

Course Description
Content is designed to define sources of law, causes of action and litigation processes related to the professional practice of radiation therapy. The interrelatedness of standards of care, law, ethical standards and competence will be examined. Law and regulations affecting the radiation therapist in employment, employment contracts and liability will be examined.

Course Objectives
At the completion of the content, the student will:

1. Compare and contrast a civil and a criminal wrongdoing.
2. Define a tort.
3. Compare and contrast intentional torts and negligence.
4. Identify the elements of a negligent act.
5. Define comparative and contributory negligence.
6. Define and describe the components of informed consent.
7. Discuss the specific problems that may arise with minors and incompetents granting consent.
8. Define *res ipsa loquitor* and its implications in radiologic sciences.
9. Describe processes of reporting equipment malfunctions and discuss manufacturer and radiation therapist liability in such circumstances.
10. Describe circumstances that allow disclosure of patient information.
11. Define liability insurance; describe the elements of a liability policy and its limitations.
12. Identify circumstances that invalidate liability insurance coverage.
13. Describe when a radiation therapist might be held to a different standard of care than a radiation oncologist or an oncology nurse.
14. Analyze the role of a scope of practice.
15. Describe the circumstances in which a radiation therapist might be an expert witness.
16. Define registration, certification and licensure of radiation therapists and radiation therapy facilities.

Course Content

I. Sources of Law: Elements of Malpractice

A. Statutes or codes

B. Malpractice
   1. Plaintiff
   2. Prosecutor
   3. Defendant
   4. Cause of action

C. Contract law

D. Tort law

E. Criminal law

F. Administrative law

G. Legal duty

H. Termination of duty

I. Standards of care
   1. Breach of duty
   2. Professional negligence
   3. Breach of contract

J. Negligent conduct and injury

K. Doctrine of *Res Ipsa Loquitur*
   1. Evolution
   2. Application in radiologic sciences

L. Damages and remedies

II. Causes of Action

A. Assault and battery

B. Slander

C. *Per Se* and *Per Quod* defamatory words

D. Rumors

E. Libel

F. Invasion of privacy

G. Against patients for payment of their bill

H. Recovering payment in injury causes

III. Defenses: Employment Issues

A. Doctrine of *Respondeat Superior*

B. Independent contractor

C. Contract law

D. Comparative negligence

E. Comparative fault

F. Assumption of risk
   1. Informed consent
   2. Implied consent
   3. Disclosure
   4. Legal incompetence
   5. Spousal consent
   6. Consent by a minor

G. Workers' compensation

H. Contract of employment

IV. Contracts

A. Formal contract

B. Implied contract

C. Principle of detrimental reliance

D. Limitations

E. Informed consent
   1. History
   2. Content

3. Reasons for noncompliance
4. Exceptions
5. Specifics for invasive procedures

F. End-of-life treatment decisions

G. Advanced directives

V. Litigation Process

A. Malicious prosecution

B. Abuse of process

C. Criminal conduct

D. Civil litigation

E. Discovery
1. Interrogatories
2. Depositions
3. Subpoenas

F. Trial
1. Procedural steps
2. Expert testimony
3. Cross-examination

Medical Terminology

Course Description
Content of this course is designed to establish a foundation in the standardized language of medical practice, including its abbreviations and symbols. A word building system will be presented preparatory to reading, understanding, interpreting and applying physician prescriptions to radiation therapy and related services.

Course Objectives
At the completion of the content outline, the student must:

1. Identify primary and secondary language sources from which medical terms derive and apply them in simulated exercises.
2. Given medical terms, operate and define each according to its basic elements.
3. Given medical terms in noun and verb forms, change each to adjective and/or adverb forms.
4. Translate medical terms into common language a patient will comprehend.
5. Provide definitions for given symbols.
6. Provide definitions for given abbreviations.
7. Translate medical orders from written abbreviations and symbols.
8. Describe procedures for diagnostic and therapeutic procedures from written orders on the patient chart.
9. Given request for radiation oncology consult/services, describe procedures and processes necessary to provide requested service(s).
10. Given specific imaging and oncology terms/procedures, provide definitions for each.
11. List examples of medical laboratory procedures.
12. Define operational and management terms and abbreviations.
13. Given selected scenarios utilizing operation and management terms and abbreviations, describe the implications for effective provision of services.
14. Interpret language, abbreviations and symbols in the medical record and radiation therapy treatment folder, translate into action steps and communicate to the patient.

Course Content

I. Introduction to the Origin of Medical Terminology

A. Primary language sources
   1. Greek
   2. Latin

B. Secondary language sources
   1. English
   2. French
   3. German

II. The Word Building Process

A. Basic elements
   1. Root words
   2. Prefixes
   3. Suffixes

B. Combining forms

C. Parts of speech
   1. Nouns
   2. Verbs
   3. Adjectives
   4. Adverbs

D. Translation of terms into common language

E. Correct pronunciation of medical terms

III. Medical Abbreviations and Symbols

A. Role in communications

B. Abbreviations
   1. Examples
   2. Interpretations

C. Symbols
   1. Greek alphabet—upper and lower case
   2. Pharmaceutical symbols and terms
   3. Mathematics/science symbols and constants
   4. Examples
   5. Interpretations

IV. Understanding Orders, Diagnostic Reports and Requests for Radiation Oncology

A. Radiographic orders/requisitions—components
   1. Procedures ordered
   2. Patient history
   3. Clinical information

B. Diagnostic reports
   1. Contents
   2. Interpretation

C. Requests/consults for radiation oncology services
   1. Components/documents
   2. Clinical data

V. Radiation Science Procedures/Terms

A. Radiographic/imaging

B. Radiation oncology and cancer

C. Nuclear medicine

D. Sonography

E. Magnetic resonance imaging

F. Computed tomography

VI. Operational/Management Terms

A. Total quality management terms
   1. Quality assurance/assessment
   2. Quality control
   3. Quality improvements
   4. Client/patient services

B. Budgeting and fiscal responsibility
   1. Current procedural terminology (CPT) codes
   2. Medicare/Medicaid/third party payor reimbursement terms
      a. Diagnostic related groups (DRG's)
      b. Prospective payment (PPO)
      c. Relative value scale (RVS)
   3. Revenues/expenditures account codes
   4. Personnel management terms

Computers in Radiologic Sciences

Course Description
Content is designed to establish knowledge, competency and skill in computing and information processing. Personal computers and network computer concepts and applications, hardware, input/output, spreadsheets, word processing, multimedia applications, data base management and integrated software will be presented. Laboratories will provide learning experiences in specific content including data capture, storage and retrieval; e-mail; telemedicine and telecommunications; the Internet and World Wide Web.

Applications in radiologic sciences related to computer imaging capture and storage, localization procedures, treatment planning, delivery and quality assurance will be presented and demonstrated. Specific content in radiation therapy may be integrated in a sequential computer applications course, in the treatment planning course or during clinical rotations in physics, medical dosimetry or treatment planning.

Course Objectives
At the completion of the content outline, the student must:

1. Discuss the history and development of computers.
2. Define terms related to computer fundamentals and components.
3. Identify types of computers.
4. Describe major functions of the central processing unit (CPU).
5. Differentiate the various input and output devices.
6. Define memory and describe the types of memory.
7. Describe computer care and preventive maintenance.
8. Define computer operation terms.
9. Discuss analog to digital conversion; distinguish between analog computers and digital computers.
10. Explain the binary function.
11. Define programming and describe its purpose.
12. Discuss the various types of software applications.
13. Compare and contrast computer imaging and applications in radiology, radiation oncology, nuclear medicine and diagnostic medical sonography.
14. Generate a curriculum vita.
15. Perform a literature search on the National Library of Medicine (NLM) database.
16. Communicate using e-mail.
17. Develop and maintain a computer database on a case mix seen in the clinical setting.

Course Content

I. History

A. Abacus

B. Mechanical

C. Electronic

II. Fundamentals

A. Types of computers
   1. General purpose
      a. Mainframe
      b. Minicomputer
      c. Microcomputer

B. Terminology and definitions

III. Components

A. Central processing unit (CPU)
   1. Arithmetic logic unit (CPU)
   2. Control unit (CU)
   3. Memory

B. Input/output devices (I/O) (peripherals)
   1. Input
      a. Punch card
      b. Punch paper tape
      c. Keyboards
      d. Video monitors
      e. Mouse
      f. Light pen
      g. Voice entered
      h. Digitizing cameras
      i. Image scanner
   2. Output
      a. Printers and plotters
      b. Cathode ray tube (CRT)
      c. Graphic displays
      d. Voice output microphone
      e. Computer output microphone

C. Primary memory/secondary data storage
   1. Primary memory
      a. Random access memory (RAM)
      b. Read only memory (ROM)
   2. Secondary storage
      a. Floppy disks
      b. Hard disks
      c. Tape

D. Computer care and maintenance
   1. Computer environment
   2. Computer catastrophes
   3. Preventive maintenance
   4. Security
      a. Passwords
      b. Limited access

IV. Operations

A. Terminology

B. Analog computers

C. Digital computers

D. Binary computers

E. Programming
   1. Definition
   2. Purpose
   3. Languages
      a. MUMPS
      b. ALGOL
      c. APL
      d. BASIC
      e. COBOL
      f. FORTRAN
      g. PASCAL
      h. PL/1
   4. Software
      a. Word processors
      b. Spreadsheet
      c. Database

d. Desktop publishers
e. Graphics
f. Integrated application programs

F. Electronic mail (e-mail)

G. Internet

H. Computer aided instruction (CAI)

I. Networks
1. Local area network (LAN) and wide area network (WAN)
2. Star, ring and bus

J. Telecommunications
1. On-line services
2. Modems

V. Computer Applications in Radiologic Sciences

A. Applications
1. Ethical and legal issues
2. Computed tomography (CT)
3. Digital radiology
4. Magnetic resonance (MR) hardware and software
5. Nuclear medicine applications
6. Radiation therapy treatment planning
7. Ultrasound applications
8. Literature search
9. Tumor registry
10. Record and monitor system (RMS), record and verify system (RVS)
11. Patient information/systems scheduling
12. 3-D
13. Picture archiving communication systems (PACs)

VI. Practicum

Radiologic Sciences Patient Care

Course Description
Content is designed to provide the student with foundation concepts and competencies in assessment and evaluation of the patient for service delivery. Psychological and physical needs and factors affecting treatment outcome will be presented and examined. Routine and emergency care procedures will be presented.

Course Objectives
At the completion of the content outline, the student must:

1. Differentiate between the roles and responsibilities of health care team members treating cancer patients.
2. Examine different psychological aspects of dying.
3. Understand the challenges of communicating with the cancer patient and family.
4. Understand the factors that influence a patient's emotional responses.
5. Formulate answers to questions frequently asked by patients.
6. Master the principles of patient safety and transfer.
7. Assess the physical condition of the patient before, during and after treatment delivery.
8. Perform procedures/examinations on patients.
9. Master the principles of infection control.
10. Recognize common medications and their actions/side effects.
11. Evaluate a patient for an adverse reaction to medication.
12. Apply the principles of medication administration.
13. Recognize and respond to medical emergencies.
14. Recognize and respond to acute situations.
15. Compare and contrast the differences in patient care during conventional imaging procedures and procedures involving contrast media.
16. Summarize the need for various types of tubes used in patient care.
17. Demonstrate the use of equipment associated with tube therapy.
18. Assess the patient before, during and after discipline-specific procedures.
19. Assess the patient before, during and after mobile radiography.
20. Assess the patient before, during and after brachytherapy procedures.
21. Apply the principles of radiation protection during brachytherapy procedures.
22. Recognize radiation side effects/complications and select the appropriate medical intervention.
23. Assess the nutritional status of the cancer patient.
24. Recognize nutritional consequences of cancer and apply medical intervention.
25. Understand the limitations of physical activity in cancer patients.
26. Select and present appropriate patient education materials.
27. Describe the importance of incorporating health promotion and wellness in daily activities.
28. Compare and contrast conventional medicine and alternative medicine.

Course Content

I. Introduction

A. The health care team
   1. Responsibilities

B. The radiology/radiation oncology team
   1. Responsibilities
   2. Scope of practice

II. Attitudes and Communication in Patient Care

A. Health-illness continuum

B. Developing professional attitudes
   1. Serve as health role models
   2. Sympathy
   3. Empathy
   4. Assertiveness

C. Communication
   1. Verbal
   2. Nonverbal
   3. Challenges in patient communication
      a. Hearing, vision and speech problems
      b. Impaired mental function
      c. Altered states of consciousness
      d. Communicating with pediatric and adolescent patients
      e. Geriatric patients
      f. Communicating under stress
      g. Cultural diversity
      h. Artificial speech
         1) Transesophageal puncture (TEP)
         2) Esophageal speech
         3) Electrolarynx devices
   4. Other factors that impede communication
      a. Colloquialism/slang
      b. Medical jargon
   5. Feedback
   6. Patient interactions
      a. Establishing communication guidelines
      b. Reducing distance
      c. Listening
      d. Using therapeutic silence
      e. Responding to the feeling and the meaning of the patient's statement

f. Restating the main idea
g. Reflecting the main idea
h. Making observations

7. Communicating with families
8. Communication with other health care professionals

D. Psychological considerations
1. Dying and death
a. Understand the process
b. Aspects of death
1) Emotional
2) Personal
3) Physical
a) pain
b) suffering
c) disability
d) deterioration
c. Stages of dying
1) Rejection
2) Denial
3) Anger
4) Bargaining
5) Acceptance
d. Patient support services
1) Family/friends
2) Pastoral care
3) Patient-to-patient support groups
4) Psychological support groups
5) Hospice
6) Health professionals
7) Community agencies
a) American Cancer Society
b) Living through Cancer
c) others
2. Patient's emotional responses
a. General behavior
b. Influencing factors
1) Age
2) Sex
3) Marital/family status
4) Socioeconomic factors
5) Cultural/religious variations
6) Physical condition

7) Self-image
8) Past life experiences
9) Beliefs
10) Attitudes
11) Prejudices
12) Self-awareness

3. Stress related "burnout"
   a. Definition
   b. Factors that increase "burnout" risk
   c. Psychologic and behavioral signs and symptoms

III. Patient/Radiation Therapist Interactions

A. Patient identification

B. Treatment procedure questions and explanations
   1. Positioning
   2. Length of procedure/treatment
   3. Audio and visual intercommunication system
   4. Room noises
   5. Immobilization devices
   6. Machine movement
   7. Machine-patient contact
   8. Machine type
   9. Application of auxiliary equipment

C. Procedures/treatment and disease side effects
   1. Psychological
      a. Disease related medications
   2. Emotional
   3. Physiological

D. Other common patient concerns
   1. Misconceptions related to radiation
   2. Abandonment
   3. Scheduling
   4. Transportation
   5. Financial

E. Interaction with family members and friends

IV. Safety and Transfer Positioning

A. Safety
   1. Fire
   2. Electrical
   3. Hazardous materials
   4. Radioactive materials
   5. Personal belongings
   6. Occupational Safety and Health Administration (OSHA)

B. Body mechanics
   1. Proper body alignment
   2. Proper movement
   3. Proper balance
   4. Practicum

C. Patient transfer and movement
   1. Assessing the patient's mobility
   2. Rules for safe patient transfer
   3. Wheelchair transfers
   4. Stretcher transfers
      a. Sheet transfer
      b. Three-carrier lift
      c. The log roll
      d. Positioning for safety, comfort and/or exams
   5. Disabled patients
   6. Geriatric patients
   7. Pediatric patients
   8. Patients with intravenous infusion
   9. Metastatic disease
   10. Practicum

D. Positioning for safety and comfort
   1. Positions
      a. Supine
      b. Protective side-lying
      c. Protective prone position
      d. Fowler's
      e. Semi-Fowler's
      f. Sims'
      g. Trendelenburg
      h. Lithotomy
      i. Knee chest
   2. Safety straps and rails

E. Restraints and immobilization methods
   1. Purpose
   2. Adult
      a. Types
      b. Applications
   3. Pediatric
      a. Types
      b. Applications

F. Accidents and incident reports

V. Evaluating Physical Needs

A. Physical needs of the patient

B. Purpose for developing evaluation skills

C. Assessing patient status

D. Physical signs

E. Vital signs
   1. Temperature
   2. Pulse
   3. Respiration
   4. Blood pressure
   5. Normal values
   6. Interfering factors
   7. Terminology
   8. Adult vs. pediatric
   9. Documentation

F. Weight

G. Review of laboratory reports

H. Practicum

VI. Patient Examination

A. Observation
   1. Patient status evaluation
   2. Records
      a. Diagnostic
      b. Chart information

B. General physical examination
   1. Purpose
   2. Preparation
   3. Procedure

C. Selected examinations/purpose and procedure
   1. Oral
   2. Rectal
   3. Pelvic
   4. Neurological
   5. Other

D. Selected procedures
   1. Papanicolaou (Pap) smear
   2. Lesion biopsy
   3. Cultures
   4. Laboratory studies/normal values
      a. Complete blood count
      b. Urinalysis
      c. Electrolytes
      d. Other
   5. Aspiration/centesis

E. Equipment/instruments
   1. Identification
   2. Care

VII. Infection Control

A. Terminology
   1. Nosocomial
   2. Communicable
   3. Infectious pathogens

B. Centers for Disease Control (CDC)
   1. Purpose

C. Cycle of infection
   1. Infectious pathogens
      a. Endopathogens
      b. Ectopathogens
   2. Reservoir of infection

3. Susceptible host
4. Transmission of disease
    a. Direct
    b. Indirect
        1) Vehicle
        2) Vector
        3) Airborne

D. Asepsis
1. Medical
    a. Definition
    b. Methods
        1) Heat
        2) Chemical
    c. Procedure
        1) Soap
        2) Water
        3) Friction
        4) Chemical disinfectants
2. Surgical
    a. Definition
    b. Growth requirements for microorganisms
    c. Methods used to control microorganisms
        1) Moist heat
            a) steam under pressure
        2) Dry heat
            a) incineration
            b) dry heat oven
        3) Gas
        4) Chemicals
        5) Ionizing radiation
    d. Procedures
        1) Opening packs
        2) Gowning/gloving
        3) Skin preparation
        4) Draping
        5) Dressing changes
    e. Packing
    f. Storage
    g. Rules for surgical asepsis

E. Practical asepsis
   1. Handling linens
   2. Wound care
      a. Cleansing
      b. Dressing
   3. Techniques
      a. Dress
      b. Hair
      c. Hand-washing
      d. Gloves
      e. Eye protection
      f. Cleaning and proper disposal of contaminated waste
   4. Practicum

F. Isolation techniques and communicable diseases
   1. Category-specific
   2. Disease-specific
   3. Universal precautions
   4. Examples
      a. Human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS)
      b. Hepatitis
         1) Type A
         2) Type B
         3) Type C
      c. Tuberculosis (TB)
      d. Other

G. Isolation patient in the department
   1. Procedure
      a. Gowning
      b. Gloving
      c. Masking
   2. Patient transfer
   3. Clean-up

H. Precautions for the compromised patient (reverse isolation)
   1. Purpose
   2. Procedure

I. Psychological considerations

VIII. Medications and Their Administration

A. Role of the radiation therapist

B. Medication information
   1. Generic name
   2. Trade name
   3. Drug information
      a. *Physician's Desk Reference* (PDR)
      b. Product information sheets
   4. Abbreviations/equivalents
   5. Pharmacology
      a. Adrenergics
      b. Adrenergic blocking agents
      c. Analgesics
      d. Anesthetics
      e. Antiarrhythmics
      f. Antibacterials
      g. Anticholinergics
      h. Anticoagulants
      i. Anticonvulsants
      j. Antidepressants
      k. Antiemetics
      l. Antineoplastics
         1) Actions and administration
            a) drugs
               i) alkylating agents
               ii) antimetabolites
                  (a) folic acid analogs
                  (b) pyrimidine analogs
                  (c) cytosine arabinoside (ARA-C)
                  (d) purine analogs
               iii) antineoplastic antibiotics
               iv) vinca alkaloids
               v) hormones
               vi) miscellaneous agents
            b) actions/side effects
               i) method of action
                  (a) alopecia
                  (b) bone marrow depression/recombinant DNA technology
                  (c) organ toxicity
                     (1) neurotoxicity
                     (2) cardiovascular toxicity
                  (d) GI disturbances
               ii) other

c) administration
i) definition of cycle
ii) dosage
iii) adjuvant
iv) neoadjuvant
v) intense (transplant)
vi) directed delivery (e.g.: monoclonal antibodies)
vii) induction of tumor differentiation
viii) clinical research
(a) phase I trials
(b) phase II trials
(c) phase III trials

m. Antifungals
n. Antihistamines
o. Antiperistaltics
p. Antipyretics
q. Antitussives
r. Barbituates
s. Cardiac depressants
t. Cardiac stimulants
u. Cathartics
v. Contrast media
w. Diuretics
x. Emetics
y. Hypoglycemics
z. Narcotics
aa. Narcotic antagonists
bb. Radioactive materials
cc. Sedatives
dd. Skeletal muscle relaxants
ee. Stimulants
ff. Tranquilizers
gg. Vasodilators

7. Nutrients, fluids and electrolytes
8. Drug absorption

C. Medication administration
1. Five right system
a. Right dose
b. Right medication
c. Right patient
d. Right time
e. Right route

2. Routes of administration
    a. Local
        1) Astringent
        2) Antiseptic
        3) Emollient
        4) Cleansing
    b. Systemic
        1) Oral
        2) Sublingual
        3) Rectal
        4) Parenteral
            a) intradermal
            b) subcutaneous
            c) intravenous
            d) intrathecal
            e) hypodermoclysis
            f) other
3. Equipment
4. Special precautions
5. Monitoring intravenous infusions
6. Charting
7. Adverse reactions
    a. Pyrogens
    b. Embolus
        1) Plastic
        2) Air
    c. Circulatory overload
    d. Allergic reactions
    e. Infiltration
    f. Shock
8. Disposal of equipment and drugs

IX. Medical Emergencies

A. Terminology

B. Emergency equipment

C. Latex reactions

D. Shock
1. Signs and symptoms
2. Types
    a. Hypovolemic

b. Septic
c. Cardiogenic
d. Neurogenic
e. Anaphylactic/allergic

3. Medical intervention

E. Diabetic
1. Hypoglycemia
a. Signs and symptoms
b. Medical intervention
2. Ketoacidosis
a. Signs and symptoms
b. Medical intervention
3. Hyperosmolar coma
a. Signs and symptoms
b. Medical intervention

F. Respiratory and cardiac failure
1. Symptoms
2. Medical intervention
3. Adult vs. pediatric
4. Crash cart

G. Airway obstruction
1. Symptoms
2. Medical intervention
3. Adult vs. pediatric

H. Cerebral vascular accident (CVA)/stroke
1. Symptoms
2. Medical intervention

I. Fainting (syncope)
1. Symptoms
2. Medical intervention

J. Convulsive seizures
1. Types
a. Petit mal
b. Grand mal
2. Symptoms
3. Medical intervention

K. Other medical conditions
   1. Epistaxis
   2. Nausea
   3. Postural hypotension
   4. Vertigo
   5. Asthma

X. Dealing With Acute Situations

A. Head injuries
   1. Four levels of consciousness
   2. Symptoms
   3. Medical intervention
   4. Adult vs. pediatric

B. Spinal injuries
   1. Assessment
   2. Transport

C. Extremity fractures
   1. Types
   2. Splints
   3. Casts
   4. Positioning
   5. Adult vs. pediatric

D. Wounds

E. Burns

XI. Patient Care For Barium Studies

A. Patient education
   1. Radiologic technologist's responsibility
   2. Standard procedure

B. Preparation for examination
   1. Diet
   2. Cathartics
   3. Enemas
      a. Saline
      b. Fleet
      c. Oil-retention
      d. Tap-water
      e. Soap suds
   4. Procedure

C. Types of contrast media
   1. Negative agents
      a. Carbon dioxide
      b. Air
      c. Oxygen
      d. Nitrous oxide
   2. Positive agent—barium sulfate
   3. Double contrast studies
   4. Ionic
   5. Non-ionic

D. Examination
   1. Upper gastrointestinal tract
   2. Lower gastrointestinal tract

E. Follow-up care

XII. Care of Patients With Tubes

A. Terminology

B. Nasogastric/nasointestinal
   1. Purpose
   2. Types
   3. Passage
   4. Location
   5. Removal
   6. Special precautions

C. Suction
   1. Purpose
   2. Emergency
   3. Equipment
   4. Procedure
   5. Adult vs. pediatric
   6. Special precautions

D. Tracheostomy
   1. Purpose
   2. Emergency
   3. Equipment
   4. Procedure
   5. Removal

6. Special precautions
7. Suction techniques
8. Cardio-pulmonary resuscitation (CPR)

E. Chest tube
1. Purpose
2. Equipment
3. Procedure
4. Removal
5. Special precautions

F. Tissue drains
1. Purpose
2. Equipment
3. Procedure
4. Removal
5. Special precautions

G. Oxygen administration
1. Purpose
2. Values
3. Oxygen therapy
4. Oxygen delivery systems
   a. Low flow systems
   b. High flow systems
5. Documentation
6. Special precautions

H. Urinary collection
1. Purpose
2. Equipment
3. Procedure
   a. Male
   b. Female
4. Removal
5. Alternative methods of urinary drainage
6. Documentation
7. Special precautions

I. Other ostomies
1. Ileostomy
2. Ureteroileostomy

XIII. Discipline-Specific Patient Care

A. Cardiac monitoring
   1. Preparation for cardiac monitoring
   2. Electrocardiogram (ECG) rhythms
   3. Patient care considerations
      a. Adverse reactions
         1) Reactions to contrast media
         2) Other medical conditions

B. Myelography
   1. Patient education
   2. Patient care
   3. Intrathecal drug administration
   4. Special precautions

C. Computerized tomography
   1. Patient education
   2. Patient care
   3. Drug administration
   4. Special precautions

D. Urography
   1. Patient education
   2. Patient care
   3. Drug administration
   4. Special precautions

E. Magnetic resonance
   1. Patient education
   2. Patient care
   3. Drug administration
   4. Interstitial/intracavitary

F. Radiation therapy
   1. Patient education
   2. Patient care
   3. Special precautions
   4. Interstitial/intracavitary
      a. Safety measures
      b. Respiratory care
      c. Nutritional care
      d. Urinary care
      e. Medications
      f. Contraindications

5. Sexual dysfunction/alternatives
    a. Male
    b. Female
6. Emergencies
    a. Superior vena cava (SVC) syndrome
    b. Spinal cord compressisons
    c. Severe tumor bleed
    d. Acute leukemic infiltrate

G. Ultrasound
1. Patient education
2. Patient care
3. Special precautions

XIV. Patient Care During Mobile Radiography

A. Patient education

B. Patient care

C. Special precautions

XV. Patient Care During Brachytherapy Procedures

A. Patient care
1. Physical and psychological response to treatment
2. Untoward effects, reactions and therapeutic responses
3. Interruption of treatment when conditions warrant
4. Providing patient care as appropriate
5. Detection, documentation and reporting significant changes in patient condition
6. Creating a safe environment for patient
    a. Radiation protection
        1) Time, distance and shielding
        2) Quality control tests for treatment equipment
        3) Detecting equipment malfunctions and taking appropriate action
    b. Universal precautions
    c. Bio-hazards
7. Follow-up patient care
    a. Expected effects
    b. Immediate effects
    c. Late effects
8. Patients/family caregiving

XVI. Radiation Side Effects

A. Factors
   1. Time dose
   2. Treatment site
   3. Combined effect with chemotherapy
   4. Site specific
   5. Other

B. Medical intervention

XVII. Treatment Area Considerations

A. Skin

B. Wound

C. Oral
   1. Complications
      a. Symptoms
         1) Mucositis
         2) Xerostomia
         3) Osteoradionecrosis
         4) Loss of taste
      b. Treatment

D. Ostomy

E. Site specific care

F. Other

XVIII. Nutrition

A. Counseling

B. Terminology
   1. Pharyngitis
   2. Mucositis
   3. Anorexia
   4. Cachexia
   5. Xerostomia
   6. Dysphagia
   7. Early satiety
   8. Nausea
   9. Vomiting
   10. Constipation

C. Types of malnutrition
   1. Primary
      a. Lack of withholding of food
      b. Types
         1) Anorexia nervosa
         2) Bulimia
   2. Secondary (malignancy-related)

D. Association of dietary factors with cancer

E. Benefits of good nutritional support to cancer patients
   1. Effect of diet on outcome of therapy

F. Types of diet
   1. Sodium regulation
   2. Residue regulation
   3. Caloric regulation
   4. Protein regulation
   5. Pre-existing diabetes
   6. Renal failure
   7. Other

G. Establishing a dietary plan
   1. Eating hints
      a. General
      b. Irradiated site specific
   2. Dietary supplements
   3. Monitor progress
   4. Documentation

H. Total parenteral alimentation
   1. Nutritional dysfunctions
      a. Anorexia
      b. Cachexia

XIX. Physical Activity Considerations

A. Karnofsky scale/performance status

B. Restrictions

C. Limitations

XX. Patient Education

A. Procedure

B. Restrictions

C. Interactions

D. Duration

E. Special instructions

XXI. Health Promotion

A. Primary disease prevention
   1. Sources of educational materials
      a. American Cancer Society
      b. National Cancer Institute
      c. American Heart Association

B. Secondary disease prevention
   1. Early detection
      a. Breast self-exam
      b. Testicular self-exam
      c. Skin self-exam
      d. Mammography
      e. Physical examinations
      f. Pelvic examination
      g. Colorectal examination
   2. Family history

C. Tertiary disease prevention

XXII. Cancer Quackery

A. Types
   1. Machines and devices
   2. Nutrition and diets
   3. Chemicals and potions
   4. Psychic and mystical methods

B. Research data and federal/state legislation on quackery

Radiation Protection

Course Description
Content is designed to present basic principles of radiation protection and safety for the radiation therapist. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated. Specific responsibilities of the radiation therapist are discussed, examined, performed and evaluated.

Course Objectives
At the completion of the content outline, the student must:

1. Identify and justify the need to minimize non-useful radiation exposure of humans.
2. Define and distinguish between somatic and genetic radiation effects.
3. Differentiate stochastic and non-stochastic effects of radiation exposure.
4. List the objectives of a radiation protection program.
5. Identify effective dose equivalent limits for occupational and non-occupational radiation exposure.
6. Describe the as low as reasonably achievable (ALARA) concept.
7. Identify the basis for occupational exposure limits, comparable risk.
8. Describe the concept of negligible individual risk level (NIRL).
9. Identify ionizing radiations from natural and man-made sources.
10. Identify legal and ethical radiation protection responsibilities of radiation workers.
11. Identify and define units of radiation for exposure, absorbed dose, dose equivalent and radioactivity.
12. Define and describe the interrelationship between relative biological effectiveness (RBE) and quality factors (QF).
13. Describe how the quality factor is used to determine dose equivalent.
14. Determine why the sievert (Sv) is the appropriate unit for radiation protection work.
15. Describe the theory and operation of the following radiation detection devices: ion-chambers, proportional counters and thermoluminescent dosimeters (TLD's).
16. List appropriate applications and limitations for each radiation detection device listed above.
17. Determine when and how a radiation protection survey should be conducted and who should conduct one.
18. Describe the conditions in which radiation protection surveys of equipment are conducted.
19. Identify performance standards for beam directing, beam defining and beam limiting devices evaluated in a radiation protection equipment survey of the following:
    a. Radiographic and fluoroscopic equipment.
    b. Gamma-beam (γ-beam) teletherapy equipment.
    c. Linear accelerators.
20. Describe procedures to verify performance standards for equipment and indicate potential consequences of performance standards failure.

21. Describe various interlocking systems for equipment and indicate potential consequences of interlock system failure.
22. List conditions and locations evaluated in an area survey for radiation protection.
23. Distinguish between controlled and noncontrolled areas and list acceptable exposure levels.
24. Describe purpose of "RADIATION AREA" signs and identify appropriate placement sites.
25. Identify the functions of the following agencies:
    a. International Commission on Radiological Protection (ICRP).
    b. National Council on Radiation Protection (NCRP).
    c. Nuclear Regulatory Commission (NRC).
    d. Others.
26. Discuss the Consumer-Patient Radiation Health and Safety Act of 1981.
27. Describe the function of various state and local regulations governing radiation protection practices.
28. Describe the requirements and responsibilities for a radiation protection officer.
29. Identify the need and importance of personnel monitoring for radiation workers.
30. Identify, describe and list applications, advantages and limitations for each device:
    a. Body badge, ring badge.
    b. Thermoluminescent dosimeters (TLD's).
    c. Pocket ionization chambers.
31. Interpret personnel monitoring reports.
32. Compare values for maximum permissible dose equivalent (MPDEs) for occupational and nonoccupational exposure limits for radiation exposures (annual and lifetime).
33. Identify structures considered critical for potential late effects for whole body irradiation exposure.
34. Identify dose equivalent limits for the embryo and fetus in occupationally exposed women.
35. State the principles that govern determination of a maximum accumulated dose equivalent.
36. Identify barrier materials and their use in specific installations.
37. Distinguish between primary and secondary barriers.
38. Describe how the following factors influence the design of installations:
    a. Use (U).
    b. Workload (W).
    c. Occupancy (T).
    d. Distance (d).
    e. Material.
39. Describe how the operation of various ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
40. Describe how the operation of various x-ray and gamma-ray equipment influences radiation safety and describe the potential consequences of equipment failure.
41. Identify who should evaluate the ancillary and x-ray equipment and indicate the frequency with which these evaluations should be made; indicate how this is related to a quality assurance (Q.A.) program for radiation safety.
42. Demonstrate how time, distance and shielding may be manipulated to reduce radiation exposure.

43. Perform calculations of exposure with varying time, distance and shielding.
44. Discuss the relationship between half-value layer (HVL) and shielding design.
45. Identify emergency procedures during failures of x-ray and gamma-ray beam control mechanisms.
46. Describe appropriate storage containers (safes) for brachytherapy sources; indicate consequences of inappropriate storage.
47. Identify appropriate inventory procedures for sources; indicate consequences of noncompliance with set procedures.
48. State the importance of maintenance procedures for applicators; indicate consequences of mechanical failures of applicators.
49. Describe techniques for loading, unloading and cleaning brachytherapy applicators; indicate consequences of poor technique.
50. Describe importance and methods of area and room surveys following brachytherapy procedures.
51. Describe leak testing of brachytherapy sources.
52. Demonstrate how brachytherapy surveys are documented.
53. Describe the radiation warning signage.
54. Describe procedures to measure, record and post radiation levels of implant patients per state and federal regulations.
55. Identify state and federal regulations for brachytherapy.
56. Describe procedures for the confinement and decontamination of brachytherapy source failure.
57. Identify personnel/agencies to be notified in case of damage or loss of a radiation source.
58. Identify personnel/agencies to be notified in case of a misadministration.

Course Content

I. Introduction

A. Justification for radiation protection

B. Biologic damage potential of ionizing radiation
   1. Somatic effects
   2. Genetic effects
   3. Stochastic and non-stochastic effects

C. Objectives of a radiation protection program
   1. Documentation
   2. Occupational and nonoccupational dose equivalent limits
   3. As low as reasonably achievable (ALARA) concept
   4. Comparable risk
   5. Negligible individual risk level (NIRL)

D. Sources of radiation
   1. Natural
   2. Man-made

E. Legal and ethical responsibilities

II. Units, Detection and Measurement

A. Physical unit of exposure

B. Biologic unit of dose

C. Unit of dose equivalent
   1. Recommendations for effective dose equivalent limits
   2. Quality factors

D. Physical unit of radioactivity

E. Measurement devices: principle/application/types
   1. Ion chambers
   2. Proportional counters
   3. Thermoluminescent dosimeter
   4. Other

III. Surveys, Regulatory Agencies and Regulations

A. General survey procedures
   1. Qualified expert
   2. Records

B. Equipment survey
   1. Conditions
   2. Radiographic and fluoroscopic equipment
   3. Gamma-beam teletherapy equipment
   4. Other teletherapy equipment, i.e., linear accelerators

C. Area survey
   1. Controlled/uncontrolled areas
   2. Conditions
   3. Recommendations
   4. "Radiation Area" sign posting

D. Regulatory agencies
   1. ICRP
   2. NCRP
   3. NCR
   4. The Consumer-Patient Radiation Health and Safety Act of 1981
   5. State agencies

E. Radiation protection officer
   1. Requirement
   2. Responsibilities

IV. Personnel Monitoring and Maximum Permissible Dose

A. Requirements for personnel monitoring

B. Methods and types of personnel monitors
   1. Film badge
      a. Body badge
      b. Ring badge
   2. Thermoluminescent dosimeters (TLD's)
   3. Pocket ionization chambers
   4. Other

C. Records of accumulated dose
   1. Purpose
   2. Content
   3. Length of record keeping
   4. Retrieval from previous employers

D. Maximum permissible dose equivalent
   1. Occupational
   2. Nonoccupational limits

3. Critical organ sites
4. Embryo-fetus
5. Age proration formula

E. Responsibility for radiation protection
1. Radiation therapist
2. Radiation safety officer (RSO)
3. Facility

V. Practical Radiation Protection

A. Design
1. Barriers
a. Materials
b. Primary
c. Secondary (scatter and leakage)
d. Mazes/doors/conduits/ducts
2. Factors
a. Use (U) controlled/uncontrolled
b. Workload (W)
c. Occupancy (T)
d. Distance (d)
3. Safety ancillary equipment
a. Interlocks
b. Visual monitors
c. Audio monitors
d. Emergency controls
e. Quality assurance
4. X-ray equipment safety
a. Beam defining equipment
b. Exposure control devices
c. On and off switches
d. Performance standards per design specifications
e. Calibrations
f. Quality assurance
g. Emergency switches/brakers

B. Regulations and recommendations
1. Current NRC recommendations and/or regulations
2. Current NCRP recommendations and/or regulations

C. Cardinal principles in protection
   1. Time
   2. Distance
   3. Shielding

D. Emergency procedures

VI. Brachytherapy

A. Storage
   1. Inventory systems
   2. Containers
   3. Room design

B. Source preparation
   1. Applicators and maintenance
   2. Preparation and loading of applicators
   3. Unloading and cleaning applicators

C. Surveys
   1. Leak testing
   2. Area/room surveys
   3. Methods, documentation, frequency

D. Licensing, transport, area posting
   1. Governmental regulations
   2. State regulations

E. Management of accidents
   1. Procedures for confinement and decontamination
   2. Notifications
   3. Records

F. Quality assurance for brachytherapy

Human Structure and Function

Course Description
Content is designed to establish a knowledge base in anatomy and physiology. Components of the cell, tissues, organs and systems will be described. Function of cell and tissue types, organs and systems will be described and discussed.

Course Objectives
At the completion of the content outline, the student must:

1. Given frontal and lateral diagrams of the human body, apply the appropriate terms that relate to direction/orientation.
2. Using frontal and lateral diagrams of the human body, demonstrate where the various planes lie in relation to the body.
3. Analyze and determine the structural limits, function and contents of each of the body cavities.
4. Explain the terms atom, ion and atomic number weight.
5. Describe the nature of chemical bonds and compare the different types of chemical bonds.
6. Analyze the pH scale and differentiate between acid and base substances.
7. Differentiate between polar and non-polar compounds and compare these to water solubility.
8. Recognize the different types of carbohydrates and, given examples, categorize them according to type of the cell membrane and the cytoskeleton.
9. Differentiate between types of lipids and determine common characteristics.
10. Analyze the structure and functions of proteins.
11. Describe the structure of deoxyribonucleic acid (DNA) and apply the law of complementary base pairing.
12. Describe the structure of ribonucleic acid (RNA) and differentiate between the types of RNA.
13. Analyze the structure of the cell membrane and the cytoskeleton.
14. Compare endocytosis and exocytosis.
15. Determine the structure and function of cilia and flagella.
16. Diagram the replication of DNA.
17. Describe lipid metabolism.
18. Describe the Krebs cycle in general terms and examine its functional significance.
19. Describe protein metabolism.
20. Determine the significance of a ketone.
21. Determine the factors that affect the basal metabolic rate.
22. Diagram the germinal layers of the embryo.
23. Differentiate between each type of tissue and determine where each type may be found within the body.

24. Compare and contrast structural and functional characteristics of each of the tissue classifications.
25. Differentiate between the following tissue types: epithelial, connective, muscle and nerve.
26. Differentiate between the various types of body membranes and determine where they are located.
27. Describe the structure of the various tissue layers of the skin.
28. List the general function of each of these skin layers.
29. Describe the accessory organs associated with the skin and identify the function of each.
30. Explain how the skin functions in the regulation of body temperature.
31. Summarize the factors that determine skin color and how the skin responds to injury.
32. Given radiographs, diagrams and skeletal parts, identify and locate the bones of the axial skeleton.
33. Describe processes and depressions on bones of the axial skeleton.
34. Describe articulations of the axial and appendicular skeleton.
35. Given radiographs, diagrams and skeleton, locate and identify structures of the skull.
36. Given radiographs, diagrams and skeleton, analyze the primary and secondary curves of the spine.
37. Given radiographs, diagrams, and skeleton, describe projections and depressions found on bones of the appendicular skeleton.
38. Describe sesmoid bones and locate examples on radiographs.
39. Determine the function of the skeletal system.
40. Define articulation.
41. Given diagrams, locate and label the different types of articulations.
42. Differentiate between the types of articulations.
43. Compare the types, locations and movements permitted by the different types of articulations.
44. Examine the organization of muscle at the gross and microscopic levels.
45. Differentiate between the structure of each type of muscle tissue.
46. Determine the function of each type of muscle tissue.
47. Name and locate the major muscles of the axial skeleton.
48. Name and locate the major muscles of the appendicular skeleton.
49. Differentiate between the structures of the different types of nerve cells.
50. Determine the function of the different types of nerve cells.
51. Analyze the structure of the brain and the relationship of its component parts.
52. Describe the brain functions.
53. List the meninges and describe the functions of each.
54. Analyze the formation, circulation and function of cerebrospinal fluid.
55. Analyze the structure and the function of the spinal cord.
56. Determine the distribution and function of cranial nerves.
57. Determine the distribution and function of spinal nerves.
58. Analyze the structure and function of autonomic nervous system components.
59. Analyze the structure and function of the eye components.
60. Analyze the structure and function of the ear components.

61. Determine the components of specific body parts involved in the sense of smell.
62. Determine the components and structure of body parts involved in the sense of taste.
63. List the somatic senses.
64. Define endocrine.
65. Analyze the characteristics and function of the endocrine system.
66. Identify the location and determine the structure of the endocrine system components.
67. Identify the major hormone(s) secreted by the components of the endocrine system.
68. Determine the function of each component of the endocrine system.
69. Describe the hard and soft palates.
70. Differentiate between deciduous and permanent teeth in terms of age for eruption and number.
71. Differentiate between types of teeth in terms of number, location within the jaws and function.
72. Given cross-sectional diagrams of teeth, label the component parts.
73. Analyze the structure and function of the tongue.
74. Analyze the structure, function and locations of the salivary glands.
75. Determine the primary organs of the digestive system.
76. Given diagrams and radiographs of primary organs comprising the digestive system, label the parts.
77. Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
78. Analyze the functions of each primary organ of the digestive system.
79. Differentiate between peritoneum, omentum and mesentery.
80. List the accessory organs of the digestive system.
81. Given diagrams and radiographs of accessory organs of the digestive system, label the parts.
82. Differentiate between the secretions of the accessory organs in terms of the function of each.
83. Analyze the function of the accessory organs of the digestive system.
84. Explain the purpose of digestion.
85. Differentiate between types of digestive changes in the body.
86. Analyze the process of absorption.
87. Given diagrams and radiographs of components of the respiratory system, label the parts.
88. Analyze the composition and characteristics of blood.
89. Describe the various functions associated with each of the component parts of blood.
90. List normal ranges for blood values.
91. Name the major branches of the coronary arteries and describe their distribution.
92. Analyze structural and functional properties of cardiac muscle.
93. Explain how cardiac muscle differs from skeletal muscle.
94. Analyze an electrocardiogram (ECG) tracing.
95. Name the individual waves and intervals and indicate what each represents.
96. Name some of the abnormalities that can be detected on an ECG tracing.
97. Analyze the structure and function of arteries.
98. Analyze the structure and function of veins and explain how veins differ from arteries.

99. Differentiate between blood flow, blood pressure and resistance and explain the relationship among the three.
100. Analyze the structure and distribution of lymphatic vessels and explain their function.
101. Describe the source of lymph and the mechanism(s) of lymph transport.
102. Given a diagram or lymphangiogram, identify the major lymph chains.
103. Name and describe the lymphoid organs of the body.
104. Compare and contrast the lymphoid organs with lymph nodes, structurally and functionally.
105. Describe the surface membrane barriers and their protective functions.
106. Explain the importance of phagocytosis and natural killer cells in nonspecific body defense.
107. Name the body's antimicrobial substances and describe their function.
108. Compare and contrast the origin, maturation process and general function of B and T lymphocytes.
109. Describe the role of macrophages in immunity.
110. Explain what an antigen is and how it affects the immune system.
111. Analyze the structure and function(s) of antibodies.
112. Describe the development and clinical uses of monoclonal antibodies.
113. Analyze the mechanisms of respiration.
114. Explain alveolar exchange.
115. Describe the transport of blood gases.
116. Explain tissue gas exchange.
117. Describe how respiration is regulated.
118. Given diagrams and radiographs, label the parts of the kidneys, ureters, bladder and urethra.
119. Determine the function of each organ of the urinary system.
120. Describe the composition of urine.
121. Explain how urine is formed.
122. Explain micturition.
123. Diagram and label the parts of the male reproductive organs.
124. Analyze the function of each of the male reproductive organs.
125. Trace the flow of seminal fluid.
126. Diagram the female reproductive organs.
127. Label the parts of the female reproductive organs.
128. Analyze the function of each of the female reproductive organs.
129. Locate and explain the functions of the mammary glands.
130. Describe the hormonal control of breast development.
131. Explain the human reproductive process.
132. Explain the ovarian and menstrual cycles.
133. Describe menopause.
134. Given a phantom, identify topographical landmarks for various body areas.
135. Given diagrams and computed tomography/magnetic resonance images of the head, label the structures.
136. Given diagrams and computed tomography/magnetic resonance images of the abdomen/pelvis, label the structures.

137. Given diagrams and computed tomography/magnetic resonance images of the vertebral column, label the structures.
138. Given diagrams and computed tomography/magnetic resonance images of the extremities, label the structures.
139. Compare imaging modalities that use sectional anatomy.

Course Content

I. Anatomical Nomenclature

A. Terms of direction
   1. Anterior/posterior
   2. Ventral/dorsal
   3. Medial/lateral
   4. Superior/inferior
   5. Proximal/distal
   6. Cephalad/caudad

B. Body planes
   1. Median/mid-sagittal
   2. Sagittal
   3. Coronal
   4. Transverse
   5. Longitudinal

C. Body cavities
   1. Thoracic
      a. Structural limits
      b. Function
      c. Contents
   2. Abdominal
      a. Structural limits
      b. Function
      c. Contents
   3. Pelvis
      a. Structural limits
      b. Function
      c. Contents

II. Chemical Composition

A. Atoms

B. Chemical bonds

C. Inorganic compounds
   1. Acids
   2. Bases
   3. Salts
   4. Acid-base balance: maintaining pH

D. Organic compounds
   1. Carbohydrates
   2. Lipids
   3. Proteins
   4. Nucleic acids
      a. deoxyribonucleic acid - DNA
      b. ribonucleic acid - RNA
   5. Adenosine triphosphate (ATP)
   6. Cyclic AMP (adenosine-3', 5'-monophosphate)

III. Cell Structure and Genetic Control

A. Cell membrane
   1. Chemistry
   2. Structure
   3. Physiology
   4. Types of transport processes
      a. Diffusion
      b. Osmosis
      c. Filtration
      d. Active transport/physiological pumps
      e. Phagocytosis and pinocytosis

B. Cytoplasm

C. Organelles
   1. Nucleus
   2. Ribosomes
   3. Endoplasmic reticulum
   4. Golgi complex
   5. Mitochondria
   6. Lysosomes
   7. Peroxisomes
   8. Cytoskeleton
   9. Centrosome and centrioles
   10. Flagella and cilia

D. Gene action
   1. Protein synthesis
   2. Transcription
   3. Translation

E. Reproduction of cells
   1. Mitosis
   2. Meiosis

F. Aberrations/abnormal cell division

IV. Metabolism

A. Anabolism

B. Catabolism

C. Enzymes and metabolism

D. Carbohydrate metabolism

E. Lipid metabolism

F. Protein metabolism

G. Regulation and homeostasis

V. Tissues

A. Embryonic layers
   1. Ectoderm
   2. Endoderm
   3. Mesoderm

B. Types of tissue
   1. Epithelial
   2. Connective
   3. Muscle
   4. Nerve

C. Tissue repair and homeostasis

VI. Integumentary System

A. Structure

B. Appendages

C. Function

D. Clinical considerations

VII. Skeletal System

A. Osseous tissue
   1. Structural organization
      a. Medullary cavity/marrow
      b. Compact bone
      c. Cancellous bone
      d. Periosteum
      e. Cartilage
   2. Development and growth
      a. Physis
      b. Diaphysis
      c. Epiphysis/epiphyseal line
      d. Metaphysis
   3. Classifications and markings
      a. Long
      b. Short
      c. Flat
      d. Irregular
      e. Processes and bony projections
      f. Depressions/openings

B. Divisions
   1. Axial
      a. Skull
      b. Hyoid bone
      c. Vertebral column
      d. Thorax
   2. Appendicular
      a. Pectoral girdle
      b. Upper extremities
      c. Pelvic girdle
      d. Lower extremities
   3. Sesmoids
   4. Functions
      a. Support
      b. Protection
      c. Movement
      d. Hemopoiesis

C. Articulations
   1. Functional classification
      a. Synarthroses
      b. Amphiarthroses

c. Diarthroses
1) Joint classifications
2) Movement

2. Structural classification
a. Fibrous
b. Cartilaginous
c. Synovial

VIII. Muscular System

A. Functions
1. Motion/movement
2. Maintenance of posture
3. Heat production

B. Types, characteristics, functions and locations
1. Smooth
2. Cardiac
3. Skeletal

XI. Nervous System

A. Introduction
1. Neural tissue
2. Function
3. Central nervous system
4. Peripheral nervous system

B. Neural tissue
1. Neurons
a. Types
b. Location
c. Functions
2. Neuroglia
a. Types
b. Location
c. Functions
3. Physiology of neural tissue
4. Information processing

C. Peripheral nervous system
1. Anatomy
2. Functions

X. Sensory System

A. General senses
   1. Nociperception
   2. Chemoreception
   3. Thermoreception
   4. Mechanoreception

B. Special senses
   1. Vision
   2. Hearing and equilibrium
   3. Olfaction
   4. Gustation
   5. Tactile
      a. Structure
      b. Function

XI. Endocrine System

A. Hormone structure, function and location

B. Homeostatic control

C. Endocrine tissue
   1. Pituitary (hypophysis) gland
   2. Pineal gland
   3. Thyroid gland
   4. Parathyroid gland
   5. Adrenal (suprarenal) glands
   6. Heart and kidneys
   7. Digestive system
   8. Pancreas
   9. Testes
   10. Ovaries
   11. Thymus
   12. Placenta

XII. Digestive System

A. Primary organs
   1. Oral cavity
      a. Structure/location
      b. Functions
   2. Esophagus
      a. Structure/location
      b. Functions

3. Stomach
    a. Structure/location
    b. Functions
4. Small intestine
    a. Structure/location
    b. Functions
5. Large intestine
    a. Structure/location
    b. Functions
6. Rectum
    a. Structure/location
    b. Functions

B. Accessory organs
1. Salivary glands
    a. Structure/location
    b. Functions
2. Pancreas
    a. Structure/location
    b. Functions
3. Liver
    a. Structure/location
    b. Functions
4. Gallbladder
    a. Structure/location
    b. Functions

C. Digestive processes
1. Ingestion
2. Peristalsis
3. Digestion
4. Absorption
5. Defecation

XIII. Cardiovascular System

A. Blood
1. Composition
    a. Cellular components
    b. Plasma
2. Clotting system
3. Hemopoiesis
4. Function

B. Heart
   1. Anatomy
   2. Function

C. Vessels
   1. Types
   2. Structure
   3. Function

XIV. Lymphatic System and Immunity

A. Lymphatic system
   1. Lymph vessels
   2. Lymphatic organs
      a. Thymus
      b. Lymph nodes
      c. Spleen
   3. Lymphatic tissue
      a. Tonsils
      b. Peyer's patches

B. Immune system
   1. Nonspecific defenses
      a. Physical barriers
      b. Phagocytic cells
      c. Immunological surveillance
      d. Complement
      e. Inflammation
   2. Humoral immunity
      a. Production
      b. Structure
      c. Function
   3. Types of immunoglobulins
      a. Regulation of immune response
         1) Monokines
         2) Lymphokines
      b. Immunological competence

XV. Respiratory System

A. Components/structure, function and location
   1. Nose and sinus cavities
   2. Pharynx
   3. Larynx
   4. Trachea

5. Bronchi
6. Lungs
7. Thorax

B. Physiology
1. Pulmonary ventilation
2. Alveolar gas exchange
3. Transport of blood gases
4. Tissue gas exchange
5. Control and regulation of respiration

XVI. Urinary System

A. Organ structure, function and location
1. Kidneys
2. Ureters
3. Bladder
4. Urethra

B. Urine
1. Physical characteristics
2. Chemical composition

XVII. Reproductive System

A. Male/structure, function and location
1. External organs
2. Internal organs

B. Female/structure, function and location
1. External organs
2. Internal organs
3. Mammary glands
4. Reproductive physiology
   a. Ovarian cycle
   b. Menstrual cycle
   c. Aging and menopause

XVIII. Topography

A. Landmarks
1. Cranium
2. Neck
3. Spine
4. Thorax
5. Abdomen

6. Pelvis
7. Extremities

B. Underlying anatomy
1. Cranium
2. Neck
3. Spine
4. Thorax
5. Abdomen
6. Pelvis
7. Extremities

XIX. Transverse Anatomy

A. Skull
1. Structures/locations
2. Imaging applications

B. Thorax
1. Structures/locations
2. Imaging applications

C. Abdomen/pelvis
1. Structures/locations
2. Imaging applications

Pathology

Course Description
Content is designed to introduce theories of disease causation and the pathophysiologic disorders that compromise healthy systems across the lifespan. Etiology, cellular and systemic pathophysiologic responses, clinical manifestations and management of acquired, immune, carcinogenic and genetic alterations in body systems will be presented.

Course Objectives
At the completion of the content outline, the student must:

Part One

1. Respond to implications of current issues, theories and etiologies of various pathophysiological diseases as they pertain to cancer therapies.
2. Assess epidemiological influence in identification and treatment of pathophysiological disorders.
3. Describe physiological response to inflammation and cell injury due to pathological insult.
4. Recognize mechanism of tissue healing and repair.
5. Differentiate between the processes involved with a variety of types of cellular injury and adaptation mechanisms.
6. Determine interactions of genetic disorders as they impact care and treatment of the patient undergoing cancer treatments.
7. Examine the involvement of genetic abnormalities in carcinogenesis.
8. Assess the influence of fluid balance in pathophysiological disorders.
9. Compare the fluid balance requirements for adult and pediatric pathologies.
10. Predict the effects of electrolytes, acid/base balance, temperature, pain and nutrition in pathophysiological disorders.
11. Compare the roles of cell-mediated, humoral and nonspecific immune responses in pathophysiological disorders.
12. Describe the immunological disorders associated with transplants.
13. Recognize signs and symptoms of "graft vs. host" disease.
14. Apply the knowledge base of specific selected pathophysiological conditions in the clinical practice of radiation therapy.
15. Develop and apply patient care interventions in the clinical practice of radiation therapy using the knowledge base.
16. Employ knowledge of human structure and function to specified disorders of the body.
17. Investigate the clinical manifestations of selected alterations in health, particularly as they relate to the care and treatment of cancer patients.
18. Participate where appropriate in the interdisciplinary management of selected cases.
19. Distinguish the pathophysiologic basis for alterations in health across the life span, especially as it impacts the care and treatment of cancer patients.

20. Interact at appropriate intellectual levels with patients, family and patient care teams as indicated by specific pathophysiological disorders affecting the care and treatment of patients with cancer.
21. Determine effective direction for patients/clients upon recognition of systemic pathophysiologic responses and clinical manifestations of alterations in health organs/systems across the lifespan.

Parts Two and Three

1. Define neoplasia.
2. Differentiate between benign and malignant neoplasms.
3. Classify neoplasms as benign or malignant given the characteristics.
4. Construct a tumor classification table based on histology, pathogenesis and tumor characteristics.
5. Compare tumor characteristics of different histologies.
6. Differentiate between the processes involved in carcinogenesis.
7. Evaluate case studies to determine possible carcinogenic factors.
8. Evaluate case studies to determine rationale used in selection of diagnostic procedures.
9. Given case studies select appropriate diagnostic procedures to be performed by providing rationale for selection.
10. Determine the stage of disease given a clinical case study.
11. Given histologic examples of varying grades, construct a table indicating characteristics of each grade level.
12. Differentiate between the staging factors for tumors located in hollow organs and those located in solid organs.
13. Formulate a rationale for a prognosis given a clinical case study.
14. Given a case study, determine the prognostic factors in order of importance.
15. Given a variety of case studies, analyze the methods of spread.
16. Given an anatomical location of a tumor, predict the methods of spread.
17. Apply basic knowledge of neoplasia to site-specific tumors.
18. Compare tumors located at different sites to establish rationale for differing tumor characteristics.

Course Content
Part I: Pathology, Physiology and Alterations in Health

I. Theories of Disease Causation

A. Current issues/ongoing research

B. Theories

C. Etiology
   1. General adaptation syndrome
   2. Psychological implication theories
   3. Infection
   4. Aging
   5. Immune
   6. Environmental
   7. Trauma

D. Epidemiology
   1. Specificity
   2. Sensitivity
   3. Predictive values
   4. Incidence
   5. Prevalence
   6. Risk

II. Inflammation and Repair

A. Inflammatory response

B. Cell injury

C. Tissue healing and repair

III. Cellular Adaptation and Injury

A. Cellular adaptation
   1. Atrophy
   2. Hypertrophy
   3. Hyperplasia
   4. Metaplasia
   5. Dysplasia

B. Cell injury
   1. Reversible cell injury
   2. Irreversible cell injury

C. Types of cell injury
   1. Hypoxic injury
   2. Injury due to physical agents
   3. Radiation injury
   4. Chemical injury
   5. Injury due to biologic agents
   6. Injury associated with nutritional imbalances

D. Repair

IV. Genetics

A. Chromosomal translocation

B. Chromosomal deletion

C. Mutations

D. Viral insertions

E. Sex-linked disorders

F. Trisomal disorders

G. Carcinogenesis

V. Homeostatic Mechanisms

A. Fluid balance
   1. Adult
   2. Pediatric

B. Electrolytes

C. Acid/base balance

D. Temperature

E. Pain response

F. Nutrition disorders
   1. Obesity
   2. Bulimia
   3. Anorexia nervosa
   4. Other disorders

VI. Immune System

A. Cell mediated immune response

B. Humoral immune response

C. Nonspecific immune response

D. Complement

E. Immunological disorders associated with transplants
   1. Graft vs. host disease

VII. Skin Disorders

A. Psoriasis

B. Eczema

C. Pressure ulcers

D. Herpes

E. Infectious diseases

F. Burns

G. Trauma

VIII. Muscle Disorders

A. Muscular dystrophy

B. Myoglobinuria

C. Trauma

IX. Bone Disorders

A. Trauma

B. Joint dysplasia
   1. Acquired
   2. Congenital

C. Talipes

D. Osteoarthritis

E. Osteoporosis

F. Osteogenesis imperfecta

G. Rickets

H. Scoliosis

X. Cardiovascular Disorders

A. General
   1. Hypertension
   2. Hypovolemic shock
   3. Aneurysms
   4. Arterial disease
   5. Venous disease
   6. Thrombophlebitis
   7. Hemorrhage
   8. Shock

B. Structural cardiac disorders
   1. Congenital defects
   2. Valvular heart disease
   3. Cardiomyopathy
   4. Rheumatic fever
   5. Endo/myo/pericarditis

C. Functional cardiac disorders
   1. Coronary artery disease
   2. Myocardial infarct
   3. Congestive heart failure
   4. Common dysrhythmias
   5. Cardiogenic shock

XI. Respiratory Disorders

A. Hypoxemia

B. Croup

C. Asthma

D. Newborn respiratory distress

E. Bronchopulmonary dysplasia

F. Aspiration

G. Pneumonia

H. Pneumothorax

I. Cystic fibrosis

J. Chronic obstructive pulmonary disease

K. Adult respiratory distress syndrome

L. Tuberculosis

M. Embolism

N. Pulmonary edema

O. Atelectasis

XII. Gastrointestinal Disorders

A. Malabsorption

B. Diarrhea

C. Constipation

D. Pyloric stenosis

E. Peptic ulcer

F. Chronic ulcerative colitis

G. Crohn's disease/regional enterocolitis

H. Gluten enteropathy

I. GI bleeding

XIII. Liver and Pancreatic Exocrine Disorders

A. Biliary atresia

B. Hepatitis

C. Cirrhosis

D. Liver failure

E. Gallstones

F. Pancreatic exocrine function

G. Pancreatitis

XIV. Metabolic/Endocrine Disorders

A. Diabetes mellitus

B. Hypo/hyper thyroid disease

C. Hypo/hyper parathyroid disease

D. Hypo/hyper adrenal disease

E. Hypo/hyper pituitary disease

F. Phenylketonuria

G. Other

XV. Renal and Urinary Disorders

A. Renal failure
   1. Chronic
   2. Acute

B. Kidney stones

C. Urinary infections

D. Neurogenic bladder

E. Obstructions

F. Glomerulonephritis

G. Nephrotic syndrome

XVI. Reproductive Systems Disorders

A. Male
   1. Benign prostatic hypertrophy
   2. Sexually transmitted diseases (STDs)

B. Female
   1. Menstrual abnormalities
   2. Endometriosis
   3. Infertility
   4. Pregnancy disorders
   5. Sexually transmitted diseases (STDs)

XVII. Hematologic Disorders

A. Anemia

B. Thrombocytopenia

C. Sickle cell anemia

D. Hemophilia

E. Polycythemia Vera

XVIII. Sensory Organ Disorders

A. Glaucoma

B. Strabismus

C. Cataracts

D. Osteosclerosis

E. Macular degeneration

XIX. Immune Disorders

A. Rheumatoid arthritis

B. Systemic lupus erythematosus

C. Immune deficiency disorders and immunodeficiency disease

D. Acquired immunodeficiency syndrome (AIDS)

E. Allergic reactions

F. Aplastic anemia

XX. Neurologic Disorders

A. Increased intracranial pressure

B. Trauma

C. Cerebral vascular accident (CVA)

D. Huntington's disease

E. Alzheimer's disease

F. Multiple sclerosis (MS)

G. Parkinson's disease

H. Myasthenia gravis

I. Guillain-Barre´

J. Amyotrophic lateral sclerosis (ALS)

K. Congenital disorders
   1. Hydrocephalus
   2. Spina bifida
   3. Myelodysplasia

L. Epilepsy

M. Psychiatric disorders
   1. Bipolar disorders
   2. Depression
   3. Schizophrenia

N. Infectious disease
   1. Meningitis
   2. Tuberculosis
   3. Hepatitis
   4. Measles
   5. Mumps

Course Content
Part II: Neoplasia

I. Definition

II. Characteristics
- A. Benign
  1. Clinical behavior
  2. Morphology
  3. Composition and growth

- B. Malignant
  1. Clinical behavior
  2. Morphology
  3. Composition and growth
  4. Paraneoplastic syndromes

III. Tumor Classification
- A. Histogenesis, pathogenesis and characteristics
  1. Epithelial
  2. Mesenchymal
  3. Hematopoietic
  4. Lymphatic
  5. Neural tissue
  6. Mixed cell

IV. Carcinogenesis
- A. Injury
  1. Mechanical
  2. Thermal

- B. Ionizing radiation
  1. Medical
  2. Background

- C. Environmental/habit

- D. Chemical

- E. Viral/HIV/AIDS

- F. Oncogenesis

- G. Other

V. Diagnostic Procedures

A. Flow cytometry

B. Carcinoembryonic antigen (CEA) testing

C. Monoclonal antibodies

D. Prostate specific antigen (PSA)

VI. Grading/staging

A. Histological grading
   1. Purpose

B. Staging
   1. Purpose
   2. Methods of tumor staging
      a. Tumor, node, metastases (TNM)
      b. Others

VII. Prognostic Factors

A. Tumor related

B. Host related

C. Medical care related

VIII. Patterns of Spread

A. Direct invasion/infiltration mechanics
   1. Pressure
   2. Lytic enzymes
   3. Mobility of malignant cells
   4. Angiogenesis factor
   5. Iatrogenic spread

B. Lymphatic

C. Blood

D. Seeding

Part III: Tumor Sites

I. Sites

A. Head and neck

B. Central nervous system

C. Respiratory system

D. Digestive system

E. Reproductive system

F. Urinary system

G. Endocrine system

H. Circulatory system

I. Skeletal system

Note: for each of the above sites, the following will be covered:

II. Site-Specific Information

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Patterns of growth

F. Metastatic behavior

G. Staging and grading system

Radiation Physics

Course Description
Content is designed to establish a basic knowledge of physics pertinent to developing an understanding of radiations used in the clinical setting. Fundamental physical units, measurements, principles, atomic structure and types of radiation are emphasized. Also presented are the fundamentals of x-ray generating equipment, x-ray production and its interaction with matter.

Course Objectives
At the completion of the content outline, the student must:

1. State the fundamental units of the English, metric and Système International d'Unites (SI) systems.
2. Define derived units of the English, metric and SI systems.
3. Given problems, convert units from one system to the other.
4. Define and describe the general principles that relate to inertia, work, energy and momentum.
5. Define derived units of the English and metric systems.
6. Perform calculations that convert units from one system to the other.
7. Describe Bohr's theory of atomic structure.
8. Discuss the characteristics and functions of a proton, neutron and electron.
9. Discuss the energy levels of the atom.
10. Define the terms relating to atomic nomenclature.
11. Compare and contrast covalent bonding and ionic bonding.
12. Describe the process of ionization.
13. Define and describe the characteristics and give an example of a mixture.
14. Define and give an example of a substance.
15. Define element.
16. Describe the characteristics of an element using the periodic table.
17. Define compound and give an example of a compound.
18. Describe the characteristics of a molecule.
19. Describe the nature of light.
20. Define and describe wavelength and frequency and how they relate to velocity.
21. Describe the electromagnetic (EM) spectrum.
22. Explain the relationship of energy and frequency to Planck's Constant.
23. Define electrical charge and describe its source.
24. Define electrical field and describe its source.
25. Explain methods of electrification.
26. Explain the Laws of Electrostatics and their application.
27. Discuss the properties of magnetism.
28. Discuss the laws of magnetism.

29. Discuss the domain theory.
30. Relate the electronic spin of an element to its potential magnetic properties.
31. Explain the principle of magnetic induction.
32. Given the list of materials, classify according to magnetic characteristics.
33. Define potential difference, current, resistance, circuit and electric power.
34. Describe the characteristics of direct and alternating currents.
35. Given a schematic diagram of a resistance circuit, label the parts.
36. Identify and apply Ohm's Law to resolve direct current problems.
37. Identity and apply power formulas to determine power consumed.
38. Describe electrical measuring devices.
39. Given a schematic diagram of a circuit, label the electrical measuring devices.
40. Describe electrical protective devices.
41. Explain the interaction between electric and magnetic fields.
42. Discuss types of electromagnetic induction.
43. Describe types and functions of generators, motors, transformers and rectification systems.
44. Compare single phase, three phase, high frequency and falling load generators in terms of radiation production and efficiency.
45. Define rectification.
46. Explain the purpose of rectification.
47. Compare solid state and vacuum tube rectification in terms of function and advantages/disadvantages.
48. Discuss the characteristics of a rotating anode in terms of description and function.
49. Discuss the characteristics of a cathode in terms of description and function.
50. Describe the construction and function of tube housing.
51. Describe the characteristics and function of cables.
52. Given a diagram of an x-ray tube, label the parts.
53. Given tube rating charts, determine maximum allowable exposure factors for various radiographic procedures.
54. Given simulated exposure factors, use an anode cooling chart to determine the anode cooling rate.
55. Given simulated exposure factors and a cooling chart, determine heat units and cooling characteristics of x-ray tube housings.
56. Describe methods to extend tube life.
57. Describe the components of a primary x-ray circuit and explain the function of each component.
58. Describe the components of a secondary x-ray circuit and explain the function of each component.
59. Describe the components of an x-ray filament circuit and explain the function of each component.
60. Given a simple diagram of a complete x-ray circuit, label the parts.
61. Discuss the components and application of automatic exposure devices.
62. State the principles of x-ray production.
63. Compare the production of bremsstrahlung with the production of characteristic radiations.

64. Describe the conditions necessary to produce x-radiation.
65. Discuss various photon interactions in terms of description of interaction, relation to atomic number and applications.
66. Define photodisintegration.
67. Discuss relationships of wavelength and frequency to beam characteristics.
68. Define units of radiation measurement and provide an example of its application.

Course Content

I. Units of Measurement

A. Fundamental units
   1. Length
   2. Mass
   3. Time
   4. Temperature

B. Derived units
   1. Area
   2. Volume
   3. Density
   4. Specific gravity
   5. Velocity

C. Systems of measurement
   1. English
   2. Metric
   3. SI

II. General Principles

A. Mass
   1. Inertia
   2. Momentum

B. Force
   1. Work
   2. Power

C. Energy
   1. Types
   2. Laws of conservation

D. Relationship between matter and energy

E. Forces of nature
   1. Gravitational
   2. Electrical
   3. Magnetic
   4. Nuclear

III. Structure of the Atom

A. Atom
   1. Size
   2. Atomic mass and energy

B. Nucleus
   1. Components
      a. Proton
      b. Neutron
      c. Other
   2. Structure
      a. Size
      b. Neutron/proton ratio
      c. Binding energy

C. Electron Shells
   1. Components
   2. Arrangements
      a. Binding energy
      b. Movement
      c. Ionization
      d. Excitation

D. Nomenclature
   1. Atomic number
   2. Mass number
   3. Isotope
   4. Isobar
   5. Isomer
   6. Isotone
   7. Ion

IV. Structure of Matter

A. Elements
   1. Definition
   2. Periodic table
   3. Nuclides

B. Compound
   1. Definition
   2. Molecule

C. Mixtures
   1. Definition
   2. Examples

V. Nature of Radiation

A. Radiation
   1. Electromagnetic
   2. Particulate
   3. Nonionizing vs. ionizing
      a. Atomic number
      b. Energy
      c. Probability

B. Radioactivity
   1. Historical introduction
   2. Half-life ($T_{½}$)
   3. Units
      a. Curie (Ci)
      b. Becquerel (Bq)
   4. Line of stability

VI. Electromagnetic Radiation

A. Nature of electromagnetic radiation
   1. Speed of light
   2. Wavelength
   3. Frequency

B. Electromagnetic spectrum
   1. Types of electromagnetic radiation
   2. X and gamma rays
      a. Energy
      b. Planck's constant

VII. Electrostatics

A. Electrical charge
   1. Definition
   2. Source
   3. Unit of charge (Coulomb)

B. Electrical field
   1. Definition
   2. Source

C. Methods of electrification
   1. Friction
   2. Contact
   3. Induction

D. Laws of electrostatics

VIII. Magnetism

A. Fields

B. Interactions with charged particles

C. Magnetic resonance

IX. Electrodynamics

A. Moving charges
   1. Potential differences
   2. Current
      a. Direct
      b. Alternating
   3. Resistance
   4. Circuit

B. Measuring devices
   1. Galvanometer
   2. Ammeter
   3. Voltmeter
   4. Electrometer
   5. Other

C. Protective devices
   1. Fuse
   2. Ground
   3. Circuit breaker
   4. Other

X. Electromagnetism

A. Interaction between electric/magnetic fields

B. Induction
   1. Self
   2. Mutual

C. Applications
   1. Generators
      a. Types
      b. Function
   2. Motors
      a. Types
      b. Function
   3. Transformers
      a. Types
      b. Function
   4. Coils
      a. Types
      b. Function

XI. Rectification

A. Definition

B. Purpose

C. Devices
   1. Solid state
      a. Function
      b. Advantages/disadvantages
   2. Vacuum tubes
      a. Function
      b. Advantages/disadvantages

D. Types
   1. Half wave
   2. Full wave
   3. Three phase

XII. Diagnostic X-ray Tubes

A. Construction
   1. Anode
      a. Description
      b. Function
      c. Stationary/rotating
   2. Cathode
      a. Description
      b. Function
   3. Tube housing
      a. Description
      b. Function

4. Thermal capacity
    a. Tube rating
    b. Anode cooling
    c. Housing cooling

XIII. X-ray Circuits

A. Primary circuit
    1. Components
    2. Function

B. Secondary circuit
    1. Components
    2. Function

C. Filament circuit
    1. Components
    2. Function

XIV. Production and Characteristics of Radiation

A. X-ray production
    1. Historical introduction
    2. Principle
    3. Processes
        a. Bremsstrahlung
        b. Characteristic
    4. Necessary conditions
        a. Source
        b. Acceleration
        c. Deceleration
    5. X-ray energy spectra
    6. Factors affecting x-ray exposure rate
        a. Tube potential
        b. Tube current
        c. Filament current
        d. Time
        e. Distance
        f. Filtration

B. Wave model

C. Quantum model

D. Interactions of photons with matter
   1. Transmission
   2. Unmodified scattering (coherent)
      a. Description of interaction
      b. Relation to atomic number
      c. Energy of incident photon and resulting product
      d. Probability
      e. Application
   3. Photoelectric effect
      a. Description of interaction
      b. Relation to atomic number
      c. Energy of incident photon and resulting product
      d. Probability
      e. Application
   4. Compton scattering
      a. Description of interaction
      b. Relation to atomic number
      c. Energy
      d. Probability
      e. Application
   5. Pair production
      a. Description of interaction
      b. Relation to atomic number
      c. Energy
      d. Probability
      e. Application
      f. Annihilation reaction
   6. Photodisintegration
      a. Description of interaction
      b. Energy
      c. Products
      d. Application

E. Clinical significance and relative importance of the various types of interactions

F. Beam characteristics
   1. Energy
   2. Attenuation
      a. Atomic number of attenuating medium
      b. Thickness of attenuating medium
      c. Scatter

G. Units of measurement
   1. Coulomb/kilogram/roentgen
   2. Gray(Gy)/rad
   3. Sievert(Sv)/(REM)
   4. Electron volt (eV)
   5. Ergs
   6. Joules

Radiation Therapy Physics

Course Description
Content is designed to review and expand concepts and theories in the radiation physics course. Detailed analysis of the structure of matter, properties of radiation, nuclear transformations, x-ray production and interactions of ionizing radiation are emphasized. Also presented are treatment units used in external radiation therapy, measurement and quality of ionizing radiation produced, absorbed dose measurement, dose distribution and scatter analysis. Class demonstrations/labs are incorporated to complement specific content areas and are focused on clinical application of theory.

Course Objectives
At the completion of the content outline, the student will:

1. Describe the construction of the Periodic Table.
2. Compare and contrast atomic structure and composition among the elements, including but not limited to particles (their location, energy level and charge), atomic number and mass number.
3. Compare and contrast isotope, isotone, isobar and isomer.
4. Explain nuclear stability and types of radioactive decay.
5. Categorize the four fundamental forces of nature.
6. Define electromagnetic (EM) radiation.
7. Describe the characteristics of the EM spectrum and the various radiations.
8. Describe and analyze the processes of ionization and excitation.
9. Define and compare radioactivity, decay constant, activity and half-life.
10. List artificially produced and naturally occurring therapeutic nuclides.
11. Differentiate the characteristics of the commonly used radiation therapy nuclides.
12. Describe, examine and analyze radioactive series and the decay schemes for commonly used radiation therapy nuclides.
13. Explain the various forms of radioactive equilibrium.
14. Solve for rate of decay, change in activity, average life and attenuation requirements.
15. Identify nuclear reactions by recognizing the projectile and radiation emitted.
16. Define fission and fusion.
17. Discuss the activation of nuclides in terms of yield, probability, activity growth and saturation activity.
18. Describe methods of artificial production of radionuclides.
19. Describe the use of radionuclides in other medical applications.
20. Discuss the purpose of the major components of a nuclear reactor.
21. Diagram a schematic of an x-ray tube.
22. Explain the function of the components of a basic x-ray circuit.
23. Discuss exposure parameters (kVp, mA and time) and their effect on beam quality and quantity.

24. Describe x-ray production for simulators and linear accelerators.
25. Describe the interactions that produce bremsstrahlung and characteristic x-rays.
26. Explain why an x-ray beam exhibits an energy spectrum.
27. Explain the factors that influence x-ray output.
28. Describe the energy ranges and characteristics of the various radiation therapy modalities (Grenz-ray through megavoltage).
29. Define, describe and diagram a linear accelerator and its basic components.
30. Describe the characteristics and advantages and disadvantages of other radiation therapy beams (betatron, cyclotron, microtron and other accelerated particles).
31. State the gamma energies and average gamma energy of Cobalt-60 (^{60}Co).
32. Define specific activity and discuss the maximum and average specific activity of a typical ^{60}Co source.
33. Describe the beam and beam edge characteristics of a ^{60}Co beam.
34. Diagram and describe the basic components of a ^{60}Co unit.
35. Describe the production and construction of a ^{60}Co source.
36. Compare and contrast the characteristics of an isotope beam and an artificially produced beam.
37. Discuss the historical development of external beam radiation therapy.
38. Explain Linear Energy Transfer (LET).
39. Define, compare and contrast photon interactions with matter.
40. Compare, contrast and classify radiations produced by direct and indirect ionization.
41. Evaluate the major influencing factors of photon beam attenuation.
42. Describe the parameters of narrow beam geometry used in the measurement of attenuation.
43. Describe and plot heteroenergetic and monoenergetic beam attenuation data.
44. Describe and calculate Half Value Layer (HVL).
45. Define *homogeneity coefficient* and explain its purpose.
46. Calculate attenuation requirements.
47. Measure the HVL of a megavoltage beam, plot the data obtained and analyze the results.
48. Discuss the clinical significance of photoelectric, compton and pair production in regard to imaging and treatment.
49. Discuss the importance of photodisintegration in regard to activation of clinical accessories and alternate shielding materials.
50. Describe the interaction of charged particles with matter.
51. Define mass stopping power.
52. Describe and diagram a Bragg curve.
53. Describe energy loss in electron interactions.
54. Describe neutron interactions, shielding requirements and dose deposition.
55. Compare and contrast the characteristics of different radiation therapy beams.
56. Define exposure in terms of the Roentgen, coulomb per kilogram and photon fluence, including its use as a primary standard.
57. Discuss the purpose and importance of the National Institute of Standards and Technology (NIST).
58. Discuss the purpose and importance of the Accredited Dosimetry Calibration Labs (ADCL).

59. Diagram and distinguish between the purpose, use, components, calibration, considerations and limitations of radiation measurement devices.
60. Explain and illustrate various radiation detection instruments, including their components and correction factors.
61. Summarize the limitations on the clinical application of the detectors based on radiation type, energy, quantity and quality.
62. Justify the appropriate type of radiation detector for given clinical applications.
63. Name special chambers commonly used in a clinical setting.
64. Differentiate between and calculate standard temperature and pressure (STP) and standard calibration temperature and pressure.
65. Explain how correction factors for chamber calibration, temperature, pressure and other factors are used to correct a chamber reading.
66. Describe considerations of and participate in external beam calibration.
67. Perform and evaluate spot checks of external beam exposure.
68. Describe an x-ray beam's spectral distribution.
69. Describe the quality of a gamma-ray (γ) beam in terms of HVL, γ energy or mean γ energy/nuclide of origin.
70. Describe beam quality for the various external beam modalities.
71. Explain and calculate the approximate mean energy of a megavoltage beam.
72. Discuss effective energy and the energy spectrum.
73. Describe how HVL is measured for megavoltage beams including materials used.
74. Describe beam filtration for the various external beam modalities, including but not limited to purpose, types of filters and their construction, energy considerations, inherent vs. added filtration and effect on HVL.
75. List direct and indirect methods used to measure kVp.
76. List clinically relevant methods of determining megavoltage beam energy.
77. Define absorbed dose.
78. Compare and contrast absorbed dose vs. exposure.
79. Explain the special and SI units used to describe absorbed dose and convert one unit to the other.
80. Discuss the relationship between Kinetic Energy Released in the Medium (KERMA), exposure and absorbed dose.
81. Describe how absorbed dose to air is calculated and discuss photon energy limitations.
82. Describe and calculate how air dose is converted to absorbed dose in tissue, including but not limited to energy considerations, applicable conversion factors, necessary instrumentation and methods.
83. Discuss the components and advantages of the Bragg-Gray Cavity Theory.
84. Discuss the clinical importance of phantom material and size when applying the Bragg-Gray Cavity Theory.
85. Compare and contrast source-skin distance (SSD) and isocentric methods of calibration.
86. Subdivide the absolute and non-absolute methods of measurement of absorbed dose, including but not limited to material, advantages and disadvantages, energy, characteristics, procedure, considerations for use and instrumentation.

87. Critique how dose distribution measured in a phantom is used to predict dose distribution in a patient.
88. Define, evaluate and discuss the composition of various phantoms (water, plastic, anthropomorphic, etc.) and the characteristics, advantages and disadvantages of different materials.
89. Describe, decipher, calculate and explain the rationale for treatment field equivalent squares, from published tables and using Sterling's formula, for open and irregular fields.
90. Explain considerations, advantages and disadvantages for various methods of approximating equivalent squares.
91. Define the factors necessary for manual treatment calculation.
92. Analyze and calculate (where appropriate) how the following factors change with field size, energy, depth and SSD. These factors include but are not limited to percent depth dose (PDD), tissue-air ratio (TAR), tissue-phantom ratio (TPR), backscatter factor (BSF) and scatter-air ratio (SAR).
93. List and define typical input/output devices used in radiation therapy planning computers.
94. Compare and contrast various treatment planning systems.

Course Content

I. Structure of Matter and Properties of Radiation

A. Review of atomic structure

1. The atom
   a. Periodic table
      1) Rows
      2) Columns
   b. Size
2. The nucleus
   a. Atomic number
   b. Unit charge
   c. Mass number
   d. Categories
      1) Isotopes
      2) Isotones
      3) Isobars
      4) Isomers
   e. Odd/even rules
   f. Line of stability
3. Distribution of orbital electrons
4. Atomic mass and energy units
5. Avogadro's number
6. Fundamental forces
   a. Strong force
   b. Electromagnetic force
   c. Weak force
   d. Gravitational force
7. Atomic energy levels
8. Nuclear forces
9. Nuclear energy levels
10. Other elementary particles

B. Particle radiation

1. Types
2. Characteristics

C. Electromagnetic radiation

1. Spectrum
2. Characteristics
3. Wave model
4. Quantum model
5. Ionization and excitation
6. Non-ionizing vs. ionizing EM radiation

D. Relevant Equations
   1. $E=1/2mv^2$
   2. $E=mc^2$
   3. $m=\frac{m_o}{\sqrt{1 - v^2/c^2}}$
   4. $c=\lambda\nu$
   5. $E=h\nu$

II. Nuclear Transformations

A. Radioactivity

B. Decay constant

C. Activity
   1. Definition
   2. Environment influence
   3. Units

D. Half-life
   1. Definition
   2. Relationship to decay constant
   3. Specific values of commonly used nuclides in radiation therapy

E. Mean life
   1. Definition
   2. Relationship to half-life

F. Radioactive series

G. Radioactive equilibrium
   1. Transient
   2. Secular

H. Modes of decay
   1. Line of stability
   2. Decay schemes
   3. Primary modes
      a. Alpha (α) particle decay
      b. Beta (β) particle decay
         1) Negatron emission (β-)
         2) Positron emission (β+)
      c. Electron capture decay

4. Secondary modes
    a. Gamma (γ)
    b. Internal conversion
    c. Isomeric transition

I. Decay equations and problems

J. Nuclear reactions
1. Alpha (α) bombardment
2. Proton bombardment
3. Deuteron bombardment
4. Neutron bombardment
5. Photodisintegration
6. Fission
7. Fusion

K. Activation of nuclides
1. Yield
2. Probability
3. Activity growth
4. Saturation activity
5. Methods of production by nuclear reactors and by acceleration
6. Relevant artificial therapeutic nuclides

L. Nuclear reactors

III. Review of Production of X-rays

A. The x-ray tube
1. The anode
2. The cathode

B. Basic x-ray circuit

C. Voltage rectification

D. Physics of x-ray production
1. Bremsstrahlung x-rays
2. Characteristic x-rays
3. Percentage relationship with energy

E. X-ray energy spectra
   1. Unfiltered
   2. Filtered
      a. Inherent filtration
      b. Added filtration

F. Spatial distribution

G. Operating characteristics
   1. Filament current
   2. Output

IV. Radiation Therapy Treatment Units (External Teletherapy)

A. X-ray and/or particle treatment beams
   1. Grenz-ray therapy
      a. Energy range
      b. Beam characteristics
         1) Maximum Dose (D_{max}) Depth
         2) Depth dose
   2. Contact therapy
      a. Energy range
      b. Tube current
      c. Treatment distance
      d. Filtration
      e. Beam characteristics
         1) D_{max} Depth
         2) Depth dose
   3. Superficial therapy
      a. Energy range
      b. Tube current
      c. Reflection target
      d. Typical treatment distance
      e. Typical filtration
      f. Typical HVL
      g. Beam characteristics
         1) D_{max} Depth
         2) Depth dose
   4. Orthovoltage therapy or deep therapy
      a. Energy range
      b. Tube current
      c. Reflection target
      d. Typical treatment distance
      e. Typical filtration

f. Typical HVL
g. Beam characteristics
    1) D_{max} depth
    2) Depth dose

5. Supervoltage therapy
    a. Energy range
    b. Resonant transformer
        1) Insulation of high voltage
        2) Transmission target

6. Megavoltage therapy
    a. Van de Graaff generator
        1) Basic design
        2) Energy range
        3) Electrical insulation
        4) Transmission target
    b. Linear accelerator
        1) Accelerator structure design
            a) traveling wave
            b) stationary wave
        2) Basic components
            a) power supply
            b) modulator
            c) master oscillator
            d) klystron vs. magnetron
            e) microwave waveguide
            f) electron gun
            g) accelerator waveguide
            h) circulator
            i) x-ray beam
            j) electron beam
            k) treatment head
            l) target and flattening filter
            m) beam collimation and monitoring
            n) bending magnet system
            o) gantry
        3) Betatron
            a) basic design
            b) energy range
            c) photon and electron beam
            d) clinical limitations
        4) Cyclotron
            a) basic design
            b) energy range of accelerated particles

c) clinical treatment beams
d) radionuclide production

5) Microtron
a) basic design
b) energy range of photons and electrons
c) advantages

7. Heavy particle beams
a. Neutrons
1) D-T generators
2) Cyclotrons
3) Linear accelerators
b. Protons and heavy ions
1) Cyclotrons
2) Linear accelerators
c. Negative pions
1) Cyclotron
2) Linear accelerator

B. Isotope beams
1. ^{60}Cobalt
a. Gamma energies and average energy
b. Review of decay scheme
c. Specific activity
d. Typical treatment distances
e. Basic components
1) Source
2) Source housing
a) beam collimation and penumbra
2. ^{137}Cesium
3. ^{226}Radium

V. Interaction of Ionizing Radiation

A. Ionization and excitation
1. Definition
2. Linear energy transfer
3. Indirect ionizing radiation
4. Direct ionizing radiation

B. Interaction of photons
1. Photon beam attenuation
a. Influencing factors
1) Absorber atomic number dependence
2) Energy dependence
3) Absorber thickness dependence

b. Measurement of attenuation
    1) Narrow beam geometry
    2) Plotting of data
        a) semilog paper
            i) monoenergetic beam
            ii) heterogeneous beam
        b) linear paper
            i) monoenergetic beam
            ii) heterogeneous beam
        c) half value layer (HVL)
        d) attenuation coefficient (μ)
            i) linear attenuation coefficient
            ii) mass attenuation coefficient
            iii) electronic attenuation coefficient
            iv) atomic attenuation coefficient
        e) relationship between HVL and μ
        f) homogeneity coefficient
        g) attenuation differential equation

2. Interactions of photons with matter
    a. Transmission
    b. Coherent scattering
    c. Photoelectric effect
        1) Associated energy range
        2) Absorption edges
        3) Probability
            a) energy dependence
            b) Z dependence
        4) Angular distribution of photoelectrons
        5) Clinical association and significance
    d. Compton effect
        1) Associated energy range
        2) Probability
            a) energy dependence
            b) Z dependence
        3) Electrons per gram
        4) Special cases of Compton
            a) direct hit
            b) grazing hit
            c) 90° photon scatter
        5) Clinical association and significance
    e. Pair production
        1) Associated energy range and energy threshold

2) Probability
a) energy dependence
b) Z dependence
3) $E=mc^2$
4) Annihilation radiation
5) Clinical association and significance

f. Photodisintegration
g. Relative importance of photon interactions

C. Interaction of charged particles
1. Mediation of coulomb force
a. Collisions with atomic electrons
1) Ionization
2) Excitation
b. Collisions with atomic nucleus
1) Bremsstrahlung
c. Particle scattering and energy loss
2. Nuclear reactions
3. Mass stopping power
4. Heavy charged particles
a. Rate of energy loss
b. Bragg peak
5. Electrons
a. Lack of Bragg peak
b. Delta rays (δ)
c. Bremsstrahlung

D. Interaction of neutrons
1. Recoil nuclei
2. Nuclear disintegration
3. Absorption material efficiency

E. Overview of comparative beam characteristics

VI. Measurement of Ionizing Radiation

A. Introduction

B. Unit of exposure
1. The Roentgen—special unit
2. Coulomb per kilogram (C/kg)
3. Photon fluence and fluence rate

C. Collection of Charge Instruments
   1. Free-air (standard) ionization chamber
      a. Primary standard
         1) National Institute of Standards and Technology (NIST)
         2) Accredited Dosimetry Calibration Labs (ADCL)
      b. Schematic of free-air chamber
         1) Electric field
         2) Ion collection plates
         3) Current
         4) Specified air volume
         5) Ionization beyond specified volume
         6) Electronic equilibrium
         7) Saturation
      c. Energy limitations
   2. Thimble chambers
      a. Function
      b. Principle of operation
         1) Air equivalence
         2) Chamber wall
            a) effective atomic number (Z_{eff})
            b) electronic equilibrium and build-up caps
         3) Central electrode
         4) Air cavity, sensitive volume and sensitivity
      c. Chamber calibration
      d. Desirable chamber characteristics
   3. Practical thimble chambers
      a. Condenser chambers
         1) Schematic
         2) Chamber sensitivity
         3) Stem effect
         4) Phantom limitations
      b. Farmer chamber
         1) Schematic
         2) Collecting volume

D. Electrometers
   1. Charge measurement
   2. String electrometer
      a. Schematic
      b. Use with condenser chamber
         1) Charging
         2) Measuring loss of charge

3. Baldwin-Farmer type electrometer
4. Others

E. Special chambers
   1. Purpose
      a. Measurement of surface dose
      b. Measurement of build-up region
   2. Extrapolation chamber
   3. Parallel-plate chamber

F. Environmental conditions
   1. Standard Temperature and Pressure (STP)
   2. Standard calibration temperature and pressure

G. Measurement of exposure
   1. NIST traceable chamber factor
   2. Temperature and pressure factor
   3. Other correction factors
   4. Scatter radiation avoidance
   5. Narrow beam geometry

VII. Quality of X-Ray Beams

A. Energy fluence (spectral distribution)

B. Clinically practical expression of beam quality
   1. Gamma ray energy or stating nuclide of origin
   2. X-ray beams
      a. Low energy beams
         1) HVL
         2) Peak kVp
      b. Megavoltage beams
         1) HVL
         2) Peak energy
      c. Average energy

C. Filters
   1. Inherent filtration
   2. Added filtration
   3. Combination filters (Thoraeus)
   4. Clinical use with low energy x-ray beams
      a. Proper placement
      b. Typical material for low energy ranges

5. Megavoltage x-ray beams
    a. Transmission target
    b. Beam flattening filter

D. Measurement of Beam Quality Parameters
1. HVL
2. Peak voltage
    a. Direct measurement
        1) Voltage divider
        2) Sphere-gap method
    b. Indirect measurement
        1) Fluorescence method
        2) Attenuation method
        3) Pentameter
3. Effective energy
4. Mean energy

E. Measurement of megavoltage beam energy
1. Clinically relevant method
    a. Percentage depth dose (PDD)
    b. Tissue-air ratios (TAR)
    c. Tissue-maximum ratios (TMR)
2. Photoactivation ratio (PAR) method

F. Measurement of energy spectrum

VIII. Measurement of Absorbed Dose

A. Radiation absorbed dose
1. Definition
2. Advantages over exposure units
3. Units
    a. Rad
    b. Gray

B. Relationship between KERMA, exposure and absorbed dose

C. Calculation of absorbed dose from exposure
1. Absorbed dose to air
2. Absorbed dose to any medium
    a. Roentgen-to-Rad conversion factor (*f* factor)
        1) Photon energy
        2) Atomic number of medium
    b. Clinical impact

3. Dose calibration with ion chamber
4. Dose measurement of exposure with ion chamber in a medium

D. Bragg-Gray cavity theory
   1. Advantages
   2. Components overview

E. Calibration of megavoltage beams overview
   1. American Association of Physicists in Medicine (AAPM) RTC Task Group 21 protocol
   2. Application of Bragg-Gray cavity theory

F. Other methods of measurement of absorbed dose
   1. Calorimetry
   2. Chemical dosimetry
   3. Solid state
      a. Thermoluminescence dosimetry
      b. Film dosimetry

IX. Dose Distribution and Scatter Analysis Overview

A. Phantoms
   1. Purpose
   2. Properties
      a. Z_{eff}
      b. Number of electrons per gram
      c. Mass density
   3. Physical properties of various phantom materials
   4. Anthropomorphic phantoms

B. Depth dose distribution
   1. Percentage depth dose
      a. Dependence on beam quality and depth
         1) Dose build up and skin sparing
         2) KERMA vs. absorbed dose
      b. Effect of field size and shape
         1) Geometric field size
         2) PDD function of field size and beam quality
         3) Square fields vs. rectangular, irregular and circular fields
            a) equivalent square tables
            b) Sterling's "Rule of Thumb" equation
            c) precautions in use of approximation equations
         4) Dependence on source-surface distance
            a) dose rate vs. PDD

b) standard distance PDD tables
c) non-standard distance
i) Mayneord F factor
ii) formula and limitations
5) Dependence on beam collimation system

2. Tissue-air ratio (TAR)
   a. Effect of distance
   b. Variation with energy, depth and field size
3. Backscatter factor (BSF)
   a. Effect of distance
   b. Effect of beam energy and field size
4. Scatter air-ratio (SAR)

Medical Imaging and Processing

Course Description
Content is designed establish a knowledge base in factors that govern and influence the production and recording of radiographic images. Radiographic film imaging and related accessories will be emphasized. Class demonstrations/labs are used to demonstrate application of theory.

Course Objectives
At the completion of the content outline, the student must:

1. Assess radiographic density on various radiographic images.
2. Given a series of radiographs, distinguish unacceptable and acceptable film densities.
3. Analyze relationships of factors affecting radiographic density.
4. Assess radiographic contrast on various radiographic images.
5. Differentiate between subject and film contrast.
6. Given a series of radiographic films, distinguish between acceptable and unacceptable contrast.
7. Analyze relationships of factors affecting radiographic contrast.
8. Assess radiographic detail on various radiographic images.
9. Differentiate between umbra and penumbra.
10. Analyze relationships of factors affecting recorded details.
11. Differentiate between shape and size distortion.
12. Given a clinical example, formulate a plan to decrease distortion.
13. Analyze relationships of factors affecting distortion.
14. Analyze relationships of factors affecting exposure latitude.
15. Given clinical examples, select the most appropriate beam limiting device to be used.
16. Evaluate beam limiting devices in terms of:
    a. Patient dose.
    b. Production of scattered radiation.
    c. Radiographic density.
    d. Radiographic contrast.
17. Evaluate beam filtration in terms of:
    a. Patient dose.
    b. Production of scattered radiation.
    c. Radiographic density.
    d. Radiographic contrast.
18. Analyze the change in the half value layer (HVL) when additional filtration is added to the beam.
19. Analyze relationships of factors affecting scattered or secondary radiation.
20. Evaluate a series of radiographic technical factors in terms of the production of scatter radiation.

21. Evaluate the effect of scattered radiation in the terms of:
    a. Patient dose.
    b. Radiographic quality.
    c. Occupational exposure.
22. Compare each type of grid in terms of:
    a. Components.
    b. Construction.
    c. Application.
    d. Advantages and disadvantages.
    e. Maintenance.
23. Given clinical situations, select the most appropriate grid.
24. Formulate a set of rules for grid use to prevent grid cut off and artifacts.
25. Assess the need for using standardized radiographic techniques.
26. Compare and contrast fixed kVp and variable kVp systems.
27. Using a phantom, formulate a technique chart using either a fixed kVp or variable kVp system.
28. Analyze relationships of exposure factors and their effects in exposure calculations.
29. Given exposure factors, calculate the photographic effect.
30. Given exposure problems, calculate:
    a. Penumbra.
    b. Magnification factor.
    c. Percent magnification.
31. Design a darkroom to include:
    a. Film transport.
    b. Ventilation.
    c. Entrance and exit.
    d. Unexposed film storage.
32. Design a radiology department film transport and processing unit.
33. Formulate a plan for darkroom safe light illumination with rationale based on radiographic film.
34. Discuss the possible causes and health implications of "darkroom chemical sensitivity."
35. Analyze the effects of processing on film quality.
36. Analyze the effects of storage on film quality.
37. Diagram a cross section of a radiographic double emulsion film.
38. Analyze the function of each component of radiographic film.
39. Diagram latent image formation as theorized by Mott and Gurney.
40. Contrast and compare the characteristic curve for two differing types of radiographic film.
41. Given clinical examples, select the most appropriate film to be used.
42. Given the characteristic curves for various radiographic film, evaluate the films for specific clinical features.
43. Analyze each type of film holder in terms of:
    a. Construction.
    b. Application.

c. Patient dose.
d. Loading/unloading.
e. Maintenance.

44. Diagram a cross section of an intensifying screen.
45. Analyze the function of each component of an intensifying screen.
46. Given clinical examples, select the most appropriate intensifying screen.
47. Formulate a set of rules to ensure a long screen life devoid of artifacts and distortion.
48. Establish a quality control program for intensifying screens.
49. Diagram a cross section of an automatic film processor.
50. Evaluate each processing system and its relationship to other systems.
51. Devise a daily quality control program for the automatic processor.
52. Given radiographs containing artifacts, determine the type of artifact, cause and preventive measures needed.
53. Formulate a plan of action for each automatic processor-caused artifact.
54. Differentiate between film, screen and processor artifacts.
55. Given a series of radiographic films containing processing artifacts, analyze the artifacts to determine the cause.
56. Compare and contrast methods of silver recovery.
57. Evaluate silver recovery security in terms of control, theft and misappropriation.
58. Describe Occupational Safety and Health Administration (OSHA) standards affecting image processing on film.

Course Content

I. Radiographic Density

A. Definition

B. Acceptable range

C. Factors
   1. mAs
   2. kVp
   3. Distance
   4. Intensifying screens
   5. Grids
   6. Beam limitation
   7. Patient considerations
   8. Processing
   9. Contrast media
   10. Heel effect

II. Radiographic Contrast

A. Definition

B. Types
   1. Long scale
   2. Short scale

C. Components
   1. Subject
   2. Film

D. Factors
   1. kVp
   2. Scattered radiation
   3. Grids
   4. Beam limitation
   5. Filtration
   6. Intensifying screens
   7. Patient considerations
   8. Distance
   9. Processing
   10. Fog
   11. Contrast media

III. Recorded Detail

A. Definition

B. Components
   1. Umbra
   2. Penumbra

C. Factors
   1. Geometric unsharpness
      a. Focal film distance
      b. Object film distance
      c. Focal spot
   2. Materials unsharpness
      a. Intensifying screens
      b. Film
   3. Motion unsharpness
      a. Voluntary
      b. Involuntary

IV. Distortion

A. Definition

B. Types
   1. Shape
      a. Foreshortening
      b. Elongation

C. Size (magnification)

D. Factors
   1. Distance
   2. Tube/part/film relationships

V. Exposure Latitude

A. Definition

B. Factors
   1. kVp
   2. Intensifying screens
   3. Film

VI. Beam Limiting Devices

A. Definition

B. Purposes

C. Types
   1. Collimators
      a. Function
      b. Applications
   2. Apertures/diaphragms
      a. Function
      b. Applications
   3. Cones
      a. Function
      b. Applications
   4. Positive beam limitation (PBL)
      a. Function
      b. Applications

VII. Beam Filtration

A. Definition

B. Rationale

C. Composition

D. Types
   1. Inherent
   2. Additional
   3. Total
   4. Compensatory
      a. Construction
      b. Applications

E. Half value layer (HVL)
   1. Definition
   2. Applications

VIII. Scattered/Secondary Radiation

A. Definition

B. Interactions

C. Factors
   1. kVp
   2. Patient considerations
   3. Beam limitation
   4. Grids
   5. Distance
   6. Contrast media

D. Effects
   1. Patient dosage
   2. Image quality
   3. Occupational exposure

IX. Control of the Remnant Beam

A. kVp Selection

B. Grids
   1. Purpose
   2. Components
   3. Construction
      a. Canting
      b. Interspace material
   4. Types
      a. Focused
      b. Unfocused (parallel)
   5. Patterns
      a. Linear
      b. Cross hatch
   6. Terms/definitions
      a. Grid radius
      b. Focal distance
      c. Focal range
      d. Convergent line
      e. Convergent point
   7. Efficiency
      a. Ratio
      b. Frequency (lines/inch)
   8. Selection
      a. kVp
      b. Patient considerations
      c. Distance
      d. Beam alignment
      e. Latitude

9. Cut off
    a. Definition
    b. Factors
10. Artifacts

C. Beam limitation

X. Technique Formation

A. Purpose
1. Standardization of exposure
2. Image consistency

B. Considerations
1. Choice of technique system
2. Patient measurement
3. Processing

C. Types
1. Optimum kVp/variable mAs
2. Variable kVp/fixed mAs
3. Automated exposure

D. Applications

XI. Exposure Calculations

A. Factors
1. Distance
2. mAs
3. kVp
4. Grids
5. Intensifying screens
6. Films
    a. Screen
    b. Non-screen
7. Focal spots

B. Calculations
1. Density/contrast
    a. Photographic effect
    b. Visual effect
2. Penumbra
    a. Average gradient
    b. Definition

3. Distortion
    a. Magnification factor
    b. Percent magnification
4. mAs reciprocity

XII. Processing Area Considerations

A. Location/construction/function
1. Centralized/decentralized
    a. Size
    b. Location
    c. Convenience
2. Daylight processing
    a. Function/operation
    b. Purpose
3. Access
    a. Maze
    b. Revolving door
4. Staffing
    a. Darkroom assistant
    b. Radiologic technologists
5. Ease of operation
    a. Layout
    b. Counter height
    c. Storage

B. Lighting
1. Safe light illumination
    a. Definition
    b. Filters
    c. Bulb size/color
    d. Testing
2. Warning lights
3. Daylight processing
    a. Location
    b. Purpose
    c. Function/operation

XIII. Film Handling and Storage

A. Processing considerations
1. Temperature
2. Humidity
3. Light
4. Radiation
5. Handling

B. Storage considerations
   1. Temperature
   2. Humidity
   3. Light
   4. Radiation
   5. Gases/fumes
   6. Handling
   7. Pressure
   8. Expiration date
      a. Purchase consideration
      b. Maximum storage time

XIV. Characteristics of Films Used in Radiographic Procedures

A. Composition
   1. Components
   2. Structure
   3. Function

B. Types
   1. Construction
   2. Applications

C. Properties
   1. Contrast
      a. Definition
      b. Influence
      c. Application
   2. Speed
      a. Definition
      b. Influence
      c. Application
   3. Latitude
      a. Definition
      b. Influence
      c. Application
   4. Recorded detail
      a. Definition
      b. Influence
      c. Application
   5. Latent image formation
      a. Definition
      b. Sensitization specks
         1) Definition
         2) Location

6. Characteristic curve
    a. Definition/purpose
    b. Sensitometric equipment
    c. Graphing
    d. Interpretation
    e. Curve construction and graphing
    f. Evaluation

XV. Film Holders and Intensifying Screens

A. Film holders
    1. Cassettes
        a. Purpose
        b. Construction
        c. Application
        d. Loading/unloading
        e. Maintenance
    2. Disposable
        a. Purpose
        b. Construction
        c. Application

B. Intensifying screens
    1. Purpose
    2. Construction/composition
    3. Principles of function
        a. Fluorescence
        b. Phosphorescence
        c. Quantum noise
        d. Film/screen contact
        e. Technical influences
    4. Classifications/application
        a. Phosphor
        b. Speed
        c. Patient dosage
    5. Maintenance
        a. Handling
        b. Cleaning
        c. Testing
        d. Evaluating

XVI. The Automatic Processor

A. Unit
   1. Purpose
   2. Structure
      a. Components
      b. Function
   3. Systems/functions
      a. Chemical
      b. Transport
      c. Replenishment
      d. Recirculation
      e. Temperature control
      f. Wash
      g. Dry

B. Processing cycle
   1. Film feed
      a. Sheet
      b. Roll
   2. Development
      a. Action
      b. Time
   3. Fixer
      a. Action
      b. Time
   4. Wash
      a. Action
      b. Time
   5. Dry
      a. Action
      b. Time
   6. Film exit

C. Maintenance/cleaning

D. Quality control

E. Documentation

F. Darkroom chemical sensitivity

XVII. Artifacts

A. Definition

B. Types

C. Causes

D. Effects

E. Preventive measures

XVIII. Silver Recovery

A. Definition

B. Rationale

C. Methods
   1. Electrolytic
      a. Process
      b. Advantages
      c. Disadvantages
   2. Metallic replacement/ion exchange
      a. Process
      b. Advantages
      c. Disadvantages
   3. Discarded film
      a. Unexposed
      b. Exposed

D. Security
   1. Control
   2. Theft
   3. Misappropriation

Radiation Biology

Course Description
Content is designed to present basic concepts and principles of radiation biology. The interactions of radiation with cells, tissues and the body as a whole and resultant biophysical events will be presented. Discussion of the theories and principles of tolerance dose, time-dose relationships, fractionation schemes and the relationship to the clinical practice of radiation therapy will be discussed, examined and evaluated.

Course Objectives
At the completion of the content outline, the student must:

1. Describe principles of cellular biology and apply to principles of radiation biology.
2. Apply laws and principles of radiation biology to the clinical practice of radiation therapy.
3. Apply principles of electromagnetic and particulate radiations to cellular interactions.
4. Distinguish between units of radiation quantities and radiobiologic measures and demonstrate correct usage.
5. Compare and contrast somatic and genetic effects of radiation.
6. Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
7. Describe radiation induced chemical reactions and analyze biologic damage.
8. Describe factors influencing radiation response of cells and tissues.
9. Apply the Laws of Bergonnie and Tribondeau to radiation biology and clinical radiation therapy.
10. Construct and evaluate charts, graphs and survival curves related to radiation biology principles.
11. Evaluate the relationship of radiation quality and dose to systemic responses.
12. Apply the principles of radiobiology to tumor cell biology and evaluate radiation effects anticipated in the clinical practice of radiation therapy.
13. Describe the relationship of time, dose, fractionation, volume and site to radiation effects.
14. Describe the use of radiation response modifiers in the clinical practice of radiation therapy.
15. Describe the principles of chemotherapy and hyperthermia and their influence on biologic effects in combination with radiation therapy.

Course Content

I. Introduction

A. Review of cell biology
   1. Basic unit of life
   2. Cell constituents
      a. Protoplasm and metabolism
      b. Organic and inorganic compounds
      c. Basic cell chemistry
   3. Cell structure
      a. Cell membrane
      b. Cytoplasm
      c. Organelles
      d. Nucleus
   4. Cell growth
      a. Mitosis
      b. Meiosis
      c. Cell cycle
      d. Differentiation

B. Types of ionizing radiations
   1. Electromagnetic radiations
      a. X-rays
      b. Gamma rays
   2. Particulate radiations
      a. Electron
      b. Neutrons
      c. Protons
      d. Negative pi-meson

C. Sources of medical radiation exposure
   1. Diagnostic radiology
   2. Dental radiology
   3. Therapeutic radiology
   4. Nuclear medicine

II. Biophysical Events

A. Specification of radiation quantities
   1. Physical units
   2. Biologic units
      a. Gray (Gy)
      b. Seivert (Sv)

B. Molecular effects of radiation
   1. Radiolysis of water
   2. Target theory
      a. Target molecules
      b. Cell death

C. The deposition of radiant energy
   1. Linear energy transfer (LET)
   2. Relative biological effectiveness (RBE)
   3. Factors influencing RBE
      a. LET
      b. Oxygen

III. Radiation Effects

A. Subcellular radiation effects
   1. Radiation effects on deoxyribonucleic acid (DNA)
      a. Types of damage
      b. Implications in humans
   2. Radiation effects of chromosomes
      a. Types of damage
      b. Implications in humans

B. Cellular radiation effects
   1. Types of cell death
      a. Interphase death
      b. Mitotic (genetic) death
   2. Other effects
      a. Mitotic delay
      b. Reproductive failure
      c. Interference of function

C. Individual radiation effects
   1. Somatic effects
      a. Short term
      b. Long term
      c. Stochastic effects
      d. Non-stochastic effects
   2. Genetic effects
      a. Mutagenesis

D. Factors influencing radiation response
   1. Determining response
   2. Lethal and sublethal response

IV. Radiosensitivity and Response

A. Law of Bergonnie and Tribondeau
   1. Differentiation
   2. Mitotic rate
   3. Metabolic rate

B. Cell survival curves
   1. Typical survival parameters
      a. Slope
      b. Shoulder
      c. Quasi-threshold
   2. Factors influencing survival curves
      a. LET
      b. Oxygen
      c. Fractionation

C. Systemic response to radiation
   1. Hemopoietic system
   2. Skin
   3. Digestive
   4. Urinary
   5. Respiratory
   6. Reproductive
   7. Nervous
   8. Other

D. Tolerance dose
   1. Minimal
   2. Maximal
   3. Mean

E. Total body irradiation (TBI)
   1. Radiation syndromes
      a. Acute
      b. Hemopoietic
      c. Gastrointestinal
      d. Central nervous system

V. Biologic Principles of Radiation Therapy

A. Tumor cell kinetics

B. Clinical radiotherapy concepts
   1. Therapeutic ratio
   2. Cell cycle age response
   3. Radiation type
      a. High LET
      b. Low LET
   4. Four R's of radiobiology
      a. Repair
      b. Repopulation
      c. Reoxygenation
      d. Redistribution
   5. Fractionation
      a. Definition
      b. Rationale
      c. Types
   6. Time-dose relationships
      a. Nominal standard dose (NSD)
      b. Isoeffect curves
      c. Rad equivalent therapy (RETS)
      d. Dose rate
      e. Alpha-beta ratios (α-β ratios)
   7. Volume
      a. Tumor volume
      b. Treatment volume
      c. Volume vs. complications
      d. Time-dose-volume relationship

C. Chemotherapeutic considerations
   1. Chemotherapy and radiation therapy
   2. Radioprotectors and sensitizers
      a. Strategy
      b. Action

D. Hyperthermia
   1. Cellular response to heat
   2. Methods of heating
   3. Interactions of heat and radiation

Principles and Practice of Radiation Therapy I

Course Description
Content is designed to provide knowledge base for assessing, comparing, contrasting and recommending the type of radiation therapy equipment, procedure and technique, patient positioning and immobilization for appropriate tumor localization and treatment delivery. The roles and responsibilities of the radiation therapist, the treatment prescription, the documentation of treatment parameters and delivery, emergency procedures and patient condition and education needs will be presented, discussed, examined, recommended and evaluated.

Course Objectives
At the completion of the content outline, the student must:

1. Compare the role, duties and functions of a radiation therapist in the 1990s with those of an individual delivering radiation therapy treatments in the 1960s.
2. List and describe the patient and personnel safety procedures that are followed in the radiation oncology department.
3. Compare the various radiographic and non-radiographic imaging methods used to localize tumors.
4. Describe each of the factors taken into consideration prior to recommending that a patient be treated with radiation therapy.
5. Compare and contrast the relationship between various anatomic tumor sites and treatment modality selection.
6. Compare and contrast the method of photon production of the various types of external beam radiation therapy equipment available.
7. Compare and contrast the radioisotope units available.
8. Compare and contrast the emergency procedures recommended by the manufacturer of each type of radiation therapy equipment.
9. Evaluate the effectiveness of the various types of patient positioning devices.
10. Break down the steps of the imaging process for radiographic and non-radiographic imaging modalities.
11. Justify the requirement for the documentation of specified treatment parameters in the radiation therapy treatment record.
12. Compare and contrast the types of beam directional equipment and their purposes and applications.
13. Compare and contrast the types of beam modifiers and their purposes and applications.
14. Compare and contrast the types of patient positioning and immobilization devices and their purposes and applications.
15. Justify a recommendation to withhold treatment due to a change in the patient's physical condition.
16. Evaluate the treatment prescription and compare it with the treatment plan to ensure accurate treatment delivery and quality patient care.

17. Assess the status of the treatment unit on an ongoing basis to detect machine malfunctions and take appropriate action.
18. Evaluate portal films and compare them with the simulation films to determine set-up accuracy and reproducibility.
19. Document all pertinent treatment parameters in the radiation therapy treatment record.
20. Initiate emergency medical procedures when a patient's condition warrants.
21. Assess educational needs of the radiation therapy patient and family to develop a plan to meet those needs.
22. Develop a community cancer awareness program.

Course Content

I. Introduction

A. Historical perspectives in the practice of radiation therapy
   1. Pioneers
   2. Professional growth
   3. Evolution of technology

B. Patient and personnel safety
   1. Patient protection
   2. Universal precautions
   3. Hazardous materials

C. Tumor localization
   1. Anatomic location
   2. Non-radiographic procedures
   3. Imaging procedures
   4. Topographic anatomy

D. Treatment considerations
   1. Location and extent of disease
   2. Age and gender factors
   3. Health status
   4. Socioeconomic and cultural factors
   5. Quality of life
   6. Protocols

E. Treatment modalities
   1. External beam
   2. Brachytherapy
   3. Systemic

II. Radiation Therapy Equipment

A. Simulators
   1. Purpose
   2. Components
   3. Method of radiation production
   4. Fluoroscopy
   5. Auxiliary devices
   6. Radiation protection
   7. Patient observation and communication
   8. Emergency procedures

B. Superficial and orthovoltage units
   1. Purpose
   2. Components
   3. Method of radiation production
   4. Energy
   5. Auxiliary devices
   6. Patient observation and communication
   7. Emergency procedures

C. Megavoltage units
   1. Linear accelerator
      a. Purpose
      b. Components
      c. Method of radiation production
         1) Photons
         2) Electrons
      d. Energy
      e. Auxiliary devices
      f. Radiation protection
      g. Patient observation and communication
      h. Emergency procedures
   2. Specialized units
      a. Stereotactic Radiosurgery
      b. Intraoperative
         1) Orthovoltage
         2) Megavoltage
      c. Heavy particle accelerators
   3. Radioisotope units
      a. Teletherapy
         1) Purpose
         2) Methods of radiation production
         3) Half-life
         4) Energy
         5) Components
         6) Radiation protection
         7) Auxiliary devices
         8) Patient observation and communication
         9) Emergency procedures
      b. Brachytherapy
         1) Types
            a) High dose rate (HDR)
            b) Medium dose rate (MDR)
            c) Low dose rate (LDR)

2) Purpose
3) Methods of radiation production
4) Half-life
5) Energy
6) Components
7) Radiation protection
8) Auxiliary devices
9) Patient observation and communication
10) Emergency procedures

D. Emerging technologies

III. Localization and Simulation

A. Patient caregiving
1. Patient care
2. Patient and family education
3. Patient safety

B. Tumor localization
1. Orthogonal films
2. Fluoroscopy
3. Contrast media
4. CT and MRI scans
5. Sonography
6. Other

C. Patient positioning and reproducibility

D. Radiographic exposure

E. Image processing

F. Treatment field delineation and measuring

G. Documentation of treatment parameters

H. Patient observation and communication

I. Emergency medical procedures

IV. Treatment Delivery Accessories

A. Beam directional devices
   1. Types
      a. Front and back pointers
      b. Field light and cross-hairs
      c. Laser lights
      d. Breast bridge
      e. Applicators and cones
      f. Other
   2. Purposes
   3. Applications

B. Beam modification devices
   1. Types
      a. Bolus
      b. Filters
         1) Wedge—universal, individual variable, dynamic
         2) Compensating
         3) Transmission
         4) Hardening filter
      c. Beam shaping
         1) Standard blocks
         2) Custom blocks
         3) Multileaf collimators
         4) Asymmetric collimators
      d. Other
   2. Purpose
   3. Construction
   4. Applications
   5. Other

C. Patient positioning and immobilization devices
   1. Types
      a. Positioning
         1) Couches
         2) Chairs
         3) Boards
            a) arm
            b) slant
            c) belly
            d) breast
            e) other

b. Immobilization
    1) Casts
    2) Masks
    3) Bite blocks
    4) Vacuum bags
    5) Stereotactic frames
    6) Other
2. Purposes
3. Construction
4. Applications
5. Emerging devices

V. Treatment Delivery

A. Patient caregiving
1. Monitor physical and psychological response to treatment
2. Report untoward effects, reactions and therapeutic responses
3. Withhold treatment when conditions warrant
4. Provide patient care as appropriate
5. Detect, document and report significant changes in patient condition
6. Create safe environment for patient
    a. Radiation protection
    b. Universal precautions
    c. Bio-hazards
    d. Environmental safety
7. Follow-up patient care

B. Interpretation of treatment prescription

C. Evaluation and interpretation of treatment plan

D. Patient transfers

E. Patient positioning
1. Anatomic positioning
2. Reproducibility
3. Stability

F. Treatment beam alignment

G. Portal imaging
1. Manual
2. Electronic
3. Emerging technologies

H. Documentation of treatment
   1. Manual
   2. Electronic

I. Patient observation and communication

J. Medical emergency procedures

K. Patient and family education

VI. Quality Assurance

A. Sources of error

B. Purpose and importance

C. Documentation/charting

D. Recording/report mechanisms

E. Equipment

Principles and Practice of Radiation Therapy II

Course Description
Content is designed to examine and evaluate the management of neoplastic disease. The epidemiology, etiology, detection, diagnosis, patient condition, treatment and prognosis of neoplastic disease will be presented, discussed and evaluated in relationship to histology, anatomical site and patterns of spread. The radiation therapist's responsibility in the management of neoplastic disease will be presented and discussed.

Course Objectives
At the completion of the content outline, the student must:

1. Evaluate the biologic and physiologic pathways associated with cancer and neoplastic disease.
2. Describe the role and scope of surgical oncology in the management of neoplastic disease.
3. Describe the role and scope of chemotherapy in the management of neoplastic disease.
4. Describe the role and scope of immunotherapy in the management of neoplastic disease.
5. Describe the role and scope of hyperthermia in the management of neoplastic disease.
6. Synthesize, evaluate and apply the therapeutic technologies and methodologies used in the multidisciplinary approaches to neoplastic disease management.
7. Analyze the rationale of radiation therapy use from a radiobiologic perspective.
8. Assess epidemiologic and etiologic information pertinent to each anatomic site.
9. Analyze and apply knowledge of dose limiting structures and routes of spread for each anatomic site.
10. Describe the observable clinical presentation of neoplastic disease associated with each anatomic site.
11. Compare detection and diagnosis mechanisms used to classify the neoplastic diseases associated with each anatomical site.
12. Apply the grading and staging systems used to classify the neoplastic diseases associated with each anatomic site.
13. Analyze the principles and practice of simulation and treatment as they apply to neoplastic diseases associated with anatomic site.
14. Describe the parameters of treatment field design and arrangement used to treat neoplastic diseases associated with each anatomic site.
15. Interpret patient acute and chronic side effects and/or complications encountered during and after a course of therapy to create a management strategy that fosters healing and comfort for neoplastic diseases associated with the anatomic sites.
16. Establish and evaluate the role of the radiation therapist in regard to the scope of practice in administering radiation therapy in the management of neoplastic diseases associated with each anatomic site.
17. Analyze the role and scope of radiation therapy used in palliative disease management to ensure patient quality of life.

18. Describe treatment regimens and fractionalization schemes used in palliative disease management.
19. Analyze the role and scope of radiation therapy used in emergency treatment applications.
20. Describe and differentiate the syndromes encountered in emergency scenarios that would use radiation therapy in their management.

Course Content

I. Introduction to Multidisciplinary Approaches to Neoplastic Disease Management

A. Biology of cancer

B. The pathophysiology of cancer

C. Principles of surgical oncology
   1. Historical perspective
   2. Curative
   3. Palliative
   4. Sites
   5. Surgical management approaches

D. Principles of chemotherapy
   1. Historical perspective
   2. Sites
   3. Chemotherapeutic management approaches

E. Principles of immunotherapy

F. Principles of hyperthermia

G. Emerging approaches

H. Principles of radiation therapy
   1. Rationale for radiation therapy
   2. Time-Dose relationship overview
   3. Biological effects of radiation
      a. Acute
      b. Chronic
   4. Oxygen enhancement ratio (OER)
   5. Linear energy transfer (LET)
   6. Relative biological effectiveness (RBE)
   7. Response modifiers

II. Radiation Therapy Treatment of Neoplastic Disease

A. Epidemiology of disease site

B. Etiology of disease site

C. Pertinent anatomy and lymphatics
   1. Dose limiting structures
   2. Routes of spread

D. Clinical presentation

E. Detection and diagnosis
   1. Imaging studies
   2. Tumor markers

F. Disease classification
   1. Basic staging
   2. Grading

G. Treatment and simulation principles

H. Conventional field and portal design/arrangement

I. Management of secondary effects
   1. Acute
   2. Chronic

J. Radiation therapist's role in disease management

K. Anatomic sites
   1. Skin
   2. Melanoma
   3. Connective tissue neoplasms
   4. Osseous neoplasms
   5. Lymphatic system
      a. Hodgkin's disease (HD)
      b. Non-Hodgkin's lymphoma (NHL)
   6. Leukemia
      a. Adult
      b. Pediatric
   7. Multiple myeloma
   8. Endocrine
   9. Respiratory
   10. Head and neck
   11. Ocular
   12. Central nervous system (CNS)
   13. Alimentary tract
   14. Gynecological
   15. Male reproductive
   16. Genitourinary

17. Breast
    a. Female
    b. Male
18. Pediatric solid neoplasms
19. Acquired immunodeficiency syndrome (AIDS) related neoplasms
20. Benign Neoplasms

III. Palliative Treatment Applications

IV. Emergency Treatment Applications

Treatment Planning

Course Description
Content is designed to establish factors that influence and govern clinical planning of patient treatment. Encompassed are isodose descriptions, patient contouring, radiobiologic considerations, dosimetric calculations, compensation and clinical application of treatment beams. Optimal treatment planning is emphasized along with particle beams, calibration and related equipment. Stereotactic and emerging technologies are presented. Class demonstrations/laboratories and projects are incorporated to complement specific content areas and are focused on clinical applications.

Course Objectives
At the completion of the content outline, the student will:

1. Compare and contrast photon isodose curves for clinically relevant photon beams.
2. Analyze the general influencing factors that contribute to and distinguish various isodose curves, including but not limited to energy, field size and collimation design.
3. Summarize external patient factors that influence a photon beam's distribution and apply isodose correction methods for oblique incidence.
4. Summarize internal patient factors that influence a photon beam's distribution and apply isodose correction methods for tissue inhomogeneities.
5. Discuss the computer methods to manipulate patient related data and beam data in the generation of treatment plans.
6. Describe and assess methods of determining a patient's external contour, definition of internal structures and volumes of interest used in treatment planning.
7. Perform manual contours on simulated patients.
8. Perform patient simulations, including marking the field on the patient and documenting the treatment parameters.
9. Given diagnostic images of selected patients, determine the rationale for the prescribed tumor and target volumes.
10. Categorize organs and tissues at risk using published Tolerance $Dose_{5/5}$ ($TD_{5/5}$) and Tolerance $Dose_{50/5}$ ($TD_{50/5}$) lists.
11. Select patient contours and input the external contour, critical structures and other internal structures into the treatment planning computer.
12. Determine when any organ/tissue exceeds its standardized tolerance level.
13. Describe, calculate and analyze how various time-dose relationships of different total dose, elapsed days, fractions, volume and organ/tissue type affect the biologic effective dose (BED) of patient treatment, including but not limited to units, considerations and limitations.
14. Define conventional or standard fractionation relative to daily dose and weekly number of treatments.

15. Describe the components of the integral dose concept and distinguish units used in its expression.
16. Define and compare the factors necessary for manual treatment calculations; Identify limitations as appropriate.
17. Analyze and calculate (where appropriate) how these factors change with change in field size, energy, beam quality, depth and source-skin distance (SSD). These factors include but are not limited to percent depth dose (PDD), tissue-air ratio (TAR), tissue-phantom ratio (TPR), backscatter factor (BSF), scatter-air ratio (SAR), scatter-maximum ratios (SMR), collimator scatter factor (S_c) and phantom scatter factor (S_p).
18. Discuss, analyze and solve, using manual and computer methods, dose calculations used in external photon beam treatment for the following: SSD technique, isocentric technique, irregular fields and moving beam technique at standard distance, non-standard distance and variable weighting, with and without wedges for various field arrangements, including but not limited to considerations and components.
19. Define the prescribed energy, field size and other prescriptive information specific to treatment calculations for external beam photon SSD clinical cases.
20. Review factors that influence treatment unit output and absorbed dose (machine factors vs. patient factors).
21. Calculate, using manual and computer methods, the absorbed dose to other points of interest, for example: maximum dose (D_{max}), exit dose, cord dose, etc.
22. Differentiate between calculated treatment time of a treatment port and actual setting of time set on a linac to accommodate output fluctuation.
23. Compare and contrast absorbed doses within a treatment volume when variations in beam weighting, beam modification, field arrangements and distances occur.
24. Diagram results of calculations for each beam in a parallel opposed pair and judge whether the absorbed dose and treatment times calculated are reasonable.
25. Describe the process of making an SAR ruler to determine applicable TAR.
26. Establish how algorithms are incorporated into treatment planning computers and what clinical information needs to be entered to calculate irregular fields.
27. Describe the clinical applications for moving beam techniques.
28. Describe and evaluate the past pointing technique, including maximum dose displacement and varying intersection points.
29. Describe, decipher, calculate and explain the rationale for treatment field equivalent squares, from published tables and using Sterling's formula, for open and irregular fields.
30. Explain considerations, advantages and disadvantages for various methods of approximating equivalent squares.
31. Describe the effect of asymmetric beam collimation on dose distribution.
32. Describe methods for determining dose distribution at points outside the treatment field.
33. Describe the dose distribution under a block due to primary transmission and internal scatter.
34. Calculate the dose to a point under a block using the computerized negative field method.
35. Evaluate, discriminate and propose changes for unacceptable treatment plans, including but not limited to change in weighting, wedges and field arrangement.

36. Explain and critique treatment plans that routinely employ boost ports.
37. Discuss, illustrate and calculate beam divergence with adjacent fields along one axis and orthogonal adjacent fields.
38. Discuss, diagram and solve the following field matching problems: Hodgkin's mantle and "inverted Y" fields, opposed lateral neck fields and anterior supraclavicular field, opposed cranial fields and spinal field, tangential breast and supraclavicular fields.
39. Evaluate the criticality of daily clinical reproducibility in matching fields.
40. Describe how to match isodose curves to determine an acceptable dosimetric distribution.
41. Describe the components of the multiple junction shift method.
42. Evaluate diagrams that show how asymmetrical jaws, half beam blocks and beam splitters are used to eliminate divergence into an adjacent field.
43. Evaluate diagrams that demonstrate how gantry angulation, collimator angulation and treatment unit head angulation are used to eliminate divergence into an adjacent field.
44. Evaluate diagrams that use penumbra generators or spoilers to provide a desired dosimetric distribution at the adjacent field junction.
45. Analyze hot and cold regions that occur with the various methods used to separate adjacent fields.
46. Analyze depth of critical organ considerations.
47. Describe how match depth influences field size and gap size in adjacent, adjacent orthogonal and parallel-opposed adjacent fields.
48. Compare measured data with predicted data.
49. Describe the procedure used to produce a gap radiograph for a permanent record and legal document.
50. Define, compare and contrast, examine and calculate for a wedge, wedge angle, hinge angle, wedge transmission factor and wedge profile, including but not limited to purpose, construction and application of various wedge systems.
51. Define, discuss and differentiate among various methods of tissue compensation, including construction, transmission, inhomogeneity correction, advantages and disadvantages.
52. Differentiate between two-dimensional and three-dimensional compensation.
53. Differentiate between a compensating wedge and a wedge filter.
54. Design and fabricate 2-D- and 3-D-compensators.
55. Calculate absorbed dose to points of interest for varying compensation.
56. Select an appropriate isodose curve for a given clinical application.
57. Describe internal and external factors that affect the shape of an isodose curve generated in a water phantom that require adjustments in a clinical application.
58. Establish criteria that would make treatment with a single beam acceptable.
59. Evaluate low energy and megavoltage clinical applications of single beam therapy.
60. Describe and critique the dose variations of parallel-opposed isodose distributions that have varying patient separations, energies and source-skin distance (SSD) vs. source-axis distance (SAD).
61. Describe the dose distribution resulting from orthogonal beams and establish where the hot spot occurs.

62. Demonstrate and discuss clinical applications when parallel opposed or orthogonal beams would be appropriate or inappropriate, including the manipulation of the beams to achieve dose uniformity and reduce the dose to critical structures in specific clinical situations.
63. Construct composite isodose curves for the following isocentric beam arrangements:
    a. Single AP with opposed laterals.
    b. Single AP with non-opposed anterior obliques.
    c. Single AP with non-opposed posterior obliques.
    d. Non-traditional three field.
64. Demonstrate and evaluate how the manipulation of the treatment parameters influences the dose distribution, including isocenter placement, weighting, energy and field size.
65. Discuss and demonstrate clinical applications of various three-beam arrangements.
66. Construct composite isodose curves for the following four-beam arrangements:
    a. AP/PA and lateral opposed pair (box technique).
    b. Oblique opposed pairs.
    c. Oblique gapped opposed pairs with two off-center isocenters.
67. Demonstrate and evaluate how the manipulation of the treatment parameters influences the dose distribution, including isocenter placement, weighting, energy and field size.
68. Discuss and demonstrate clinical application of various four-beam arrangements.
69. Distinguish isodose distributions for the following using various beam energies:
    a. 360° rotation.
    b. 180° arc.
    c. 270° arc.
    d. Skip arcs.
70. Compare advantages and disadvantages of moving beam to stationary beam arrangements, including patient set-up, use of blocks and integral dose.
71. Discuss and demonstrate field size influences on the high dose volume and dose fall off.
72. Discuss and demonstrate clinical applications of various moving beams.
73. Discuss and demonstrate the influences of a wedge (or wedges) on dose distribution in the following:
    b. Wedged pair parallel opposed.
    b. Single wedge parallel opposed (or tangential).
    c. Wedged pair orthogonal.
    d. Open/wedged orthogonal.
    e. Open/wedged opposed laterals.
    f. Wedged pair and off-center single AP.
    g. Wedged arc (flying wedges).
74. Evaluate and assess advantages and disadvantages of dose distribution in the previous beam arrangements in regard to:
    a. Dose uniformity in the target volume.
    b. The irradiated volume.
    c. Dose to critical structures.
75. Critique the advantages/disadvantages of combined treatment planning approaches.

76. Demonstrate how composite isodose summations are generated in a treatment planning computer system.
77. Prepare hand-summed composite plans for:
    a. Parallel opposed.
    b. Three beam.
    c. Wedged beam.
78. Compare hand-summed composite plans to computer generated plans using the same patient contour.
79. Evaluate and assess misadministration of planned dose distributions.
80. Evaluate anatomy that is encompassed within the tumor volume, target volume, treatment volume and the irradiated volume.
81. Differentiate among the treatment planning terms: maximum dose, minimum dose, mean dose, modal dose and median dose, used to describe dose variations within the target volume.
82. Evaluate the dose distribution within the target volume for a variety of treatment plans.
83. Evaluate the dose distribution to surrounding non-critical and critical organs/tissues and judge whether it lies outside of acceptable $TD_{5/5}$ and $TD_{50/5}$ values.
84. Describe International Commission on Radiological Units (ICRU) recommendations on dose variance within a target volume and the effect that variances may have on cure rates, local control and tolerance.
85. Interpret dose histograms.
86. Evaluate a treatment plan that is no longer viable because of patient changes, such as weight loss or inflammation.
87. Assess the consequences of dosimetric errors that lead to overdosing or underdosing a patient.
88. Conclude what the impact is on patient outcome when correction is made due to a misadministration.
89. Analyze the physical characteristics of an electron beam.
90. Compare and contrast electron beam depth dose characteristics for various energies, including but not limited to D_{max}, fall off, skin dose and change in isodose shape with change in field size and/or energy.
91. Describe why standard published percentage depth dose data (for photons or electrons) cannot be used in clinical practice.
92. Compare and contrast why tumor depth is a more critical factor with an electron beam than it is with a photon beam.
93. Differentiate between standard treatment distance and virtual distance.
94. Describe how an electron stream is turned into an electron beam.
95. Summarize why equivalent squares used with photon beams are inappropriate with electron beams. Calculate central axis depth dose using the square root method and compare to measured data and equivalent square data.
96. Describe how tissue inhomogeneities affect equivalent path length.
97. Evaluate absorbed dose within inhomogeneities and calculate coefficient of equivalent thickness (CETs) for tissues with increased and decreased density.

98. Compare and contrast photon and electron beams, including but not limited to skin dose, types of and use of bolus and relative biological effectiveness (RBE).
99. Analyze the effect that surface irregularities have on dose distribution.
100. Formulate clinical advantages and disadvantages of electron beam treatment.
101. Establish why electron beam energy would need to be decelerated and how a decelerator is used.
102. Describe the problems of adjacent electron fields and an electron field adjacent to a photon field and appraise field matching considerations.
103. Analyze what shielding materials and what thickness would be needed to attenuate electron beams to appropriate levels in given situations.
104. Diagram how electron shielding materials should be arranged for external vs. internal shielding.
105. Analyze changes in dose rate and dose distribution with changes in blocking extent, shielding thickness and electron energy.
106. Compare "rule of thumb" calculations in lead to thicknesses based on measured data for electron beams.
107. Determine why specific isodose lines are prescribed for various clinical situations involving critical and non-critical structures.
108. Calculate "rule of thumb" percentage depth dose for 10%, 50% and 80% lines for various electron energies.
109. Prepare treatment plans with single electron beam (with and without a compensator), multiple adjacent beams and mixed beams and analyze the distributions.
110. Describe the considerations in the clinical application of special electron treatments, including total skin irradiation and arc therapy.
111. Perform manual and computer assisted electron beam calculations at non-standard distances.
112. Describe and compare the general isodose pattern of a neutron beam, a low linear energy transfer (LET) charged particle beam, a high LET charged particle beam and a heavy ion beam to photon isodose curves and each other.
113. Appraise the amount of penumbra present in the different particle beams and dose to structures above and beyond the target volume.
114. Compare clinical usefulness of particle beams to other beam types, including the dose gradients related to energy and Bragg peak, tissue inhomogeneity, patient immobilization and penumbra.
115. Perform an area survey for a lost source.
116. Perform an area survey for a reading at a specified distance from a brachytherapy patient.
117. Assist in performing an output calibration under the supervision of a qualified physicist.
118. Perform an output spot check and judge whether output is appropriate for patient treatment.
119. Discuss the purpose of quality control/assurance and applicable legal considerations associated with treatment unit calibration.
120. Describe beam flatness and symmetry specifications and evaluate a clinical beam with the assistance of a qualified physicist.
121. Review the difference between absolute and comparative dose measurement.

122. Evaluate the purpose of establishing treatment unit calibration protocols.
123. Discuss the frequency of treatment unit calibration and detector calibration.
124. Discuss why output data cannot be transferred for use on multiple, identical treatment units.
125. Subdivide the components necessary to measure output in a water phantom and examine how environmental and other corrective factors affect readings.
126. Define radiosurgery.
127. Discuss and describe the types of process and procedure used to deliver radiation for radiosurgery, including but not limited to equipment used, type and rationale of immobilization and types of head frames.
128. Describe the use of CT, MR, and arteriograms in tumor localization and planning, including but not limited to linear distortion and its effect on MR images and tumor outlines and images from the radiologist that are digitized for treatment planning.
129. Discuss entering isocenters and associated volume implications and hot spots.
130. Discuss beam shaping, multiple isocenters and weighting techniques used to accommodate the treatment volume shape.
131. Discuss computer systems best suited to radiosurgery treatment planning.
132. Discuss how the isocenter is localized using a floor stand or couch-mounted head frame and the X, Y and Z coordinates for patient set-up.
133. Identify common neoplasms treatable by radiosurgery.
134. State typical doses employed for the various neoplasms.
135. Identify vital structures that must be considered during treatment planning.
136. Discuss advantages and disadvantages of radiosurgery vs. traditional surgery.
137. Compare single dose delivery to fractionated dose delivery schedules.
138. Discuss isocenter stability and patient immobilization critical to fractionated treatments.
139. Define conformal radiation therapy.
140. Discuss the types of equipment used to deliver radiation for conformal therapy.
141. Explain why immobilization is critical in conformal therapy vs. standard radiation therapy procedures.
142. Describe the use of CT and MR in tumor localization and planning, including the advantages and disadvantages of each.
143. Describe how the tumor outlines critical structures and vital structures that are digitized for treatment planning, including isocenter placement and associated volume implications and hot spots, beam shaping, multiple isocenters and weighting techniques to accommodate the treatment volume.
144. Discuss the computer system features necessary for conformal therapy treatment planning.
145. Identify common sites amenable to conformal therapy and the typical doses employed for those sites.
146. Describe how 3D conformal therapy plans differ from traditional plans.
147. Discuss advantages and disadvantages of conformal vs. traditional radiation therapy.
148. Discuss different methods of implementing conformal therapy.
149. Discuss methods of evaluating conformal therapy plans.
150. Discuss the importance of portal imaging in conformal therapy.

Course Content

I. Isodose Descriptions and General Influencing Factors

A. Influencing factors
1. Radiation type
2. Beam energy
3. Field size
4. Collimator design
5. Source to skin distance (SSD)
6. Source to collimator distance (SCD)
7. Source size
8. SSD/source to axis distance (SAD)/normalization methods
9. Beam flattening filter, blocking and other beam attenuators
10. Bolus
11. Surface dose
12. Maximum dose (D_{max}) depth

B. Photon beams and general dose distributions at D_{max}, central axis and off-axis
1. Photon beams
   a. Low energy x-ray
      1) Diagnostic
      2) Superficial
      3) Orthovoltage
   b. Gamma
      1) Cobalt-60 (^{60}Co)
   c. Megavoltage x-ray
      1) Types
         a. linear accelerator
      2) Without beam flattening filter
      3) With beam flattening filter
      4) Flatness and symmetry definitions
      5) Overflattening/underflattening
   d. Field size definition (50% Isodose line)
   e. Build up dose region for various energies

C. Influencing external patient factors
1. Oblique incidence of patient/beam defined
2. Isodose correction methods
   a. Isodose shift (%/*k* factor)
   b. Effective attenuation coefficient
   c. Effective SSD
   d. Tissue-air ratio (TAR)/tissue maximum ratio (TMR) method
   e. Other
3. Limitations of various methods
4. Isodose correction performance exercises

D. Influencing Internal Patient Factors
   1. Tissue inhomogeneities
   2. Beam type/energy
   3. Equivalent path length
   4. Isodose correction methods
      a. Isodose shift
         1) Percent
         2) *n* factor
      b. TAR ratio
      c. Power law TAR ratio
      d. Other
   5. Isodose correction performance exercises

E. Treatment planning computer
   1. Handling of CT (Hounsfield) numbers
   2. Algorithms
   3. Measured data
   4. Patient individualization

II. Patient Contours

A. External contour
   1. Methods
      a. Solder wire
      b. Plastics
         1) Aquaplast tube
      c. Casting
         1) Plaster
         2) Light weight resin materials
         3) Thermal molding
      d. SSD
      e. Electronic
         1) CT
         2) Ultrasound
         3) Laser light
         4) Computer assisted
      f. Pantograph
      g. Other
   2. Precautions and comparative accuracy of contouring methods (phantom slice)
   3. Contouring demonstration/performance exercises

B. Internal contours
   1. Defining tumor and target volume
      a. Orthogonal radiographs

b. Diagnostic radiographs
c. CT images
d. MR images
e. Nuclear medicine images
f. Sonograms
g. Other

2. Defining organs and tissues at risk
3. Performance exercises entering tumor, target and critical structures into contour

III. Radiobiologic Dosimetric Considerations

A. Alternate fractionation schedules
1. TDF/Rad equivalent therapy (rets)
2. Alpha-beta ratios
3. Limitations of concepts

B. Integral dose concepts

C. Edge effect

D. Ret calculation performance exercises

IV. Methods of Dosimetric Calculations

A. SSD techniques (percentage depth dose, PDD)
1. Definition
2. Concepts and basic formulas/equations
3. Influencing factors
a. Isodose factors
b. Distance factor application
c. Mayneord's "F" factor
4. Percentage depth dose (PDD) calculation performance exercises (manual and computer assisted)
a. Absorbed dose calculation
1) Entrance dose
2) Exit dose
3) Entrance/exit dose summation
4) Area of interest dose
a) target volume dose
b) critical organ dose
c) dose at any point/depth
b. Treatment setting calculation
1) Time
2) Time adjustment
a) source decay

b) shutter error
c) dose rate constancy

5. Monitor unit
   a. Weighted fields

B. Isocentric techniques (SAD)
   1. Tissue-air ratio (TAR)
      a. Definition
      b. Concept
      c. Field size definition
      d. Physical factors in common with PDD techniques
   2. Factors affecting TAR value
      a. Beam energy
      b. Field size
      c. Depth
   3. Tissue-maximum ratio (TMR)
      a. Definition
      b. Concept/energy limitation of TAR
      c. Tissue-phantom ratio concept
      d. Application
         1) Tissue output ratios
            a) output factor
            b) collimator scatter factor (S_c)
         2) Interchangability/derivation of factors
         3) Phantom scatter correction factor (S_p) (field size factor)
         4) Formulas, equations
   4. TAR/TMR calculation performance exercises (manual and computer assisted)
      a. Absorbed dose calculation
         1) Entrance dose
         2) Exit dose
         3) Entrance and exit dose summation
         4) Area of interest dose
            a) target volume dose
            b) critical organ dose
            c) dose at any point/depth
      b. Treatment unit settings calculation
         1) Time
         2) Monitor units
      c. Weighted fields

C. Irregular field technique
   1. Calculation techniques
      a. Clarkson's method

1) Scatter-air ratio (SAR)
   a) definition
   b) factors affecting SAR value
   c) applicable clinical situations
2) Scatter-maximum ratio (SMR)
   a) definition
   b) application
   c) approximation method—effective field/collimator field

b. SAR, SMR and approximation calculation performance exercises (manual and computer assisted)
   1) Suggested exercises (mantle and "inverted Y" field)
   2) Applicable formulas and equations
   3) "Construct" a TAR
   4) Practical application and fabrication of a SAR ruler
   5) Computer algorithms
   6) Absorbed dose calculation
      a) entrance dose
      b) exit dose
      c) entrance and exit dose summation
      d) area of interest dose
         (1) target volume dose
         (2) critical organ dose
         (3) dose to multiple patient points/depths
   7) Treatment unit settings calculation
      a) time
      b) monitor units
   8) Weighted fields

D. Moving beam techniques
   1. Definition
   2. Concepts, basic formulas and equations
   3. Dose rate at isocenter (average TAR/TMR)
   4. Correction of first and last TAR/TMR ray values
   5. Monitor unit per degree (Gantry rotation speed)
   6. Rotation/arc calculation exercises (manual and computer assisted)
      a. Absorbed dose calculation
         1) Dose at isocenter
         2) Target dose specifications
         3) Maximum dose displacement (Arcs) (past-pointing)
      b. Treatment unit settings calculation
         1) Time
         2) Monitor units
         3) Monitor unit/degree

E. General dosimetric calculation exercises applicable to any technique
   1. Equivalent area
   2. Sterling's formula and its limitations
   3. Dose outside treatment field
   4. Dose under block
   5. Asymmetric fields

V. Prevention of Overdose and Underdose

A. General beam arrangement

B. Hot and cold spot elimination or reduction
   1. Additional treatment ports
      a. Traditional
      b. 3D-conformal therapy
   2. Field constriction ports
   3. Boost ports
   4. Past pointing
   5. Wedges/tissue compensators/bolus
   6. Shadow blocks
   7. Table angulation and calculation of angle

C. Methods of field separation to correct for beam divergence into other fields
   1. Definitions
   2. General guidelines
      a. Assessment of tumor/critical organ/surgical scar at junction
      b. Surface vs. depth considerations
      c. Daily reproducibility guidelines
   3. Methods
      a. Adjacent field junctions
         1) Geometric divergence gap calculation
         2) Matching of isodose curves
         3) Multiple junction shift methods (moving gap)
         4) Asymmetrical jaws
         5) Half-beam/rotating beam block (beam splitter)
         6) Gantry angulation (non-opposed central axis abutment)
         7) Treatment unit head angulation (non-opposed central axis abutment)
         8) Penumbra generators (spoilers, wedges)
         9) Other
      b. Orthogonal field junctions
         1) Asymmetrical jaws
         2) Half-beam block (beam splitter)
         3) Geometric

4) Table angulation and collimator angulation
5) Penumbra generators
   a) spoilers
   b) wedges
   c) assessment and limitations of methods
      (1) hot/cold regions above and below junction point
      (2) depth of critical organ considerations
      (3) final field size(s) vs. gap size(s)
      (4) measured data vs. predicted data
   d) legal documentation considerations
      (1) permanent records
      (2) gap radiographs
      (3) record and verify
   e) performance exercises for methods and gap radiograph

VI. Wedge Filters (2-Dimensional Compensation)

A. Definition
   1. Wedge angle
   2. Hinge angle
   3. Wedge transmission factor
   4. Wedge profile

B. Wedge systems—varieties in clinical use
   1. Individual
   2. Universal
   3. Variable
   4. Dynamic

C. Purpose
   1. Tissue compensation
   2. Elimination of hot spots in distribution
   3. Use of multiple non-coplanar fields

D. Construction/application
   1. Materials
   2. Design
   3. Beam placement

E. Dose calculation performance exercises
   1. Comparisons—wedged vs. non-wedged
   2. Clinical application

F. Mock wedge construction performance exercise

VII. Tissue Compensators (2- and 3-Dimensional Compensation) (XYZ)

A. Definition

B. Purposes

C. Compensator transmission factor

D. Partial field compensation advantage—beam placement

E. Construction/application
   1. Materials (attenuation coefficients)
   2. Loss of scatter at a distance
   3. Density ratio (compensator thickness ratio)

F. Demonstration/performance exercises
   1. Construction of 2-D and 3-D tissue compensators
   2. Calculate absorbed dose to points of varying compensation

VIII. Clinical Applications of Treatments Beams and Accessories

A. Selection of appropriate isodose curve for clinical application
   1. Influencing parameters of isodose curve selection
      a. Field separation
      b. Radiation type
      c. Beam energy
      d. Field size
      e. Distance
      f. Penumbra
      g. Treatment outcome goal
      h. Treatment technique (SSD/SAD)
   2. Application of isodose curve to patient contour
      a. Evaluation and assessment of special considerations requiring adjustment
         1) Oblique incidence
         2) Tissue inhomogeneity
         3) Weighting
         4) Wedge/compensator placement
         5) Blocking of normal tissue
         6) Partial blocking of low tolerance diseased tissue
         7) Bolus

B. Single beam and summation of isodose curves for multi-beam planning
   1. Single beam delivery
   2. Two beam delivery
      a. Parallel opposed
      b. Orthogonal

c. Deliverance matched orthogonals
d. Non-opposed/non-orthogonal

3. Three beam delivery
   a. Single AP with opposed laterals at central isocenter
   b. Single AP with non-opposed anterior obliques
   c. Single AP with non-opposed posterior obliques
   d. Other
4. Four beam delivery
   a. AP/PA and lateral opposed pairs with central isocenter (box technique)
   b. Oblique opposed pairs with central isocenter
   c. Oblique gapped opposed pairs with two off-center isocenters
5. Rotation and arc delivery
   a. 360° rotation
   b. 180° arc
   c. 270° arc
   d. Skip arcs
6. Wedged beam delivery
   a. Wedged pair parallel opposed
   b. Single wedge parallel opposed (or tangential)
   c. Wedged pair orthogonal
   d. Open/wedged orthogonal
   e. Open/wedged opposed laterals
   f. Wedged pair and off-center single AP
   g. Wedged arc (flying wedges)

C. Evaluation and assessment of dose distributions
   1. Target volume dose uniformity
   2. Irradiated volume doses
   3. Critical structure doses
   4. Advantages/disadvantages of listed beam arrangements

D. Planning of combinations
   1. Advantages/disadvantages of combined treatment approaches
      a. Beam arrangements
      b. Beam energies

E. Manual/computer assisted performance/exercises
   1. Demonstration
      a. Evaluation and assessment of all listed complex composite computer generated isodose summations
   2. Performance
      a. Generation of computer assisted composite plans
         1) Without wedges
         2) With wedges

b. Hand-summed composite plans
    1) Parallel opposed
    2) Three beam
    3) Wedged beam
    4) Four beam (optional)
    5) Rotation/arc (optional)
c. Hand-summation vs. computer generated comparisons
d. Evaluation and assessment of various wedge angle/hinge angle placements on dose distribution
e. Evaluation and assessment of misadministrations on planned dose distribution

3. Exercises

IX. Optimal Treatment Planning Considerations, Evaluation and Implementation

A. Definitions
1. Tumor volume
2. Target volume
3. Treatment volume
4. Irradiated volume
5. Maximum dose within target volume
6. Minimum dose within target volume
7. Mean (average) dose within target volume
8. Modal dose within target volume
9. Median dose within target volume

B. Evaluation and assessment of dose distribution within target volume

C. Evaluation and assessment of dose distribution for critical organs/tissues ($TD_{5/5}$ and $TD_{50/5}$)

D. Evaluation and assessment of dose distribution for non-critical organs/tissues

E. International commission on radiological units and measurements (ICRU) recommendations for dose distribution variance within target volume

F. Dose distribution effects on cure rates/local control/tolerance

G. Dose histograms

H. Evaluation and assessment of advantages/disadvantages of a given treatment plan

I. Evaluation and assessment of treatment plan due to patient change (weight loss/inflammation)

J. Evaluation and assessment of consequences of dosimetric errors and recording

K. Implementation of error correction post occurrence and evaluation of patient impact

X. Particle Beams and General Dose Distributions at D_{max}, Central Axis and Off-Axis

A. Electron beam

1. Physical characteristics
   a. Rapid dose build-up (ratio of surface to D_{max} dose)
   b. Dose fall-off (low vs. high energy)
   c. Constriction of isodose curve at depth (field size)
   d. Ballooning of isodose curve at depth
   e. Percentage depth dose data unique to treatment unit, cone and field size
   f. Field size relationship to central axis pdd
      1) Energy $\leq$ 20 mev
      2) Energy > 20 mev
   g. Criticality of choosing beam energy with electrons vs. photons
   h. Distance (standard vs. virtual)
   i. Scatter
      1) Scattering foil(s), scanning magnet, air
      2) Brems photon contamination of electron beam
      3) Collimator opening effect on dose rate
   j. Equivalent area
      1) Equivalent squares
      2) Square root method
      3) Measured data
   k. Equivalent path length
2. Biological considerations in patient treatment
   a. Skin sparing effect
   b. Absorbed dose within inhomogeneity
      1) Bone, lung and air cavities
      2) Coefficient of equivalent thickness (CET)
   c. Relative biological effectiveness
   d. Prescribed dose relative to x-ray dose
   e. Reported Bragg peak-like incidences
   f. Surface irregularities
      1) Effect on central axis percentage depth dose
      2) Effect on general dose distribution
   g. Clinical advantages/disadvantages of electron beam
3. Energy decelerators for special treatment
4. Build up bolus
5. Adjacent fields

6. Shielding materials, thicknesses, energy and dose relationship
    a. Mass stopping power (low vs. high Z)
        1) Density, Z number and electrons per gram
        2) Material choices and rationales
    b. External shielding
    c. Internal shielding (tissue interfaces)
    d. Changes in dose rate and dose distribution
    e. Thickness rule of thumb (MeV/3 = mm pb)
7. Treatment prescriptions and calculations
    a. Physician prescription to specific isodose line
    b. Critical structure
    c. Non-critical structure
    d. Rules of thumb for determining PDD
        1) 0 - 10% isodose line (MeV/2)
        2) 80% isodose line (MeV/3)
        3) 50% isodose line (depth x 2.5)
8. Applications of electron beam
    a. Single beam
        1) With compensation
        2) Without compensation
    b. Multiple beams
        1) Mixed (photon and electron)
        2) Abutting
            a) electron fields
            b) electron and photon fields
    c. Complex
        1) Electron arc
        2) Total skin irradiation
9. Electron beam calculation performance exercises (manual and computer assisted)
    a. Basic formulas/equations
    b. Percentage depth dose tables
    c. Virtual source distance (effective SSD)
    d. Output factors
    e. Square root method
    f. Output tables for blocked field in cone
    g. Other
    h. Absorbed dose calculation
    i. Treatment unit settings calculation
        1) Time
        2) Monitor unit (mu)

B. Other particle beams
   1. Neutrons
      a. General isodose curve pattern
      b. Percentage depth dose energy dependence
      c. Penumbra and adjacent structures
      d. Limited use clinically
   2. Low LET charged particles (protons/helium ions)
      a. Non-exponential attenuation
      b. Proximal and distal dose gradients
      c. General isodose curve pattern
      d. Bragg peak advantage
      e. Inhomogeneity sensitivity
      f. Percentage depth dose energy dependence
      g. Precision immobilization requirements
      h. Limited penumbra—sparing adjacent structures
      i. Clinical applications
   3. High LET charged particles (negative pions)
      a. Non-exponential attenuation
      b. Proximal and distal dose gradients
      c. General isodose curve pattern
      d. Bragg peak/star effect advantage
      e. Percentage depth dose energy dependence
      f. Precision immobilization requirements
      g. Penumbra
      h. Clinical applications
   4. Heavy ions
      a. Types
         1) Carbon
         2) Neon
         3) Argon
         4) Silicon
      b. Non-exponential attenuation
      c. Proximal and distal dose gradients
      d. General isodose curve pattern
      e. Bragg peak advantage
      f. Percentage depth dose energy dependence
      g. Precision immobilization requirements
      h. Penumbra
      i. Clinical applications

XI. Treatment Unit Calibration and Related Equipment

A. Gas filled ionization chambers
   1. Simple ionization regions
      a. Recombination region (region 1)
         1) No instruments
         2) Rationale
      b. Saturation region (region 2)
         1) Pocket dosimeter
         2) Gold-leaf electroscope
         3) Free-air ionization chamber
         4) Cutie pie
         5) Extrapolation chamber (failla)
         6) Cictoreen condensor r-meter
         7) Baldwin-Farmer chamber
         8) Dose calibrators
         9) Parallel-plate chamber
   2. Gas amplification regions
      a. Proportional region (region 3a)
         1) Proportional counter
         2) Amplification factor
         3) Radiation type discrimination (pulse height)
         4) Gases
         5) Voltage sensitivity
      b. Limited proportional region (region 3b)
         1) No instruments
         2) Rationale
      c. Geiger region (region 4)
         1) GM (Geiger-Mueller) counter
         2) Amplification factor
         3) Avalanching (Townsend cascade)
         4) Quenching
         5) Gases
         6) Dead time
      d. Continuous discharge region (region 5)

B. Electrometers

C. Other radiation detector systems/measurement methods
   1. Scintillation detectors
   2. Solid-state systems
      a. Solid-state diodes
      b. Thermoluminescence dosimetry
      c. Film dosimetry
   3. Calorimetry
   4. Chemical dosimetry

D. Procedures
   1. Limitations of the various detectors
   2. Clinical use of the appropriate detector for the situation, treatment unit and radiation type
   3. Interpretation of detector reading

E. Performance exercise using detectors
   1. Area survey
   2. Output calibration/spot check

F. Purpose of treatment unit calibration
   1. Quality assurance/control
   2. Legal considerations
   3. Flatness/symmetry specifications
   4. Absolute vs. comparative dose measurement
   5. National Bureau of Standards calibration
   6. A.A.P.M. approved calibration labs
   7. Treatment unit calibration protocols (e.g.: TG21 N_{gas}, C_e, C_λ)
   8. A.A.P.M. chamber recommendations (protocol 20)
   9. Detector and treatment unit calibration to maintain accurate readings and to meet federal/state standards/regulations
   10. Frequency of calibration
   11. Transfer of output data between treatment units
   12. Preferred medium—water
   13. Application of correction factors in determining output
      a. Environmental factors
         1) Temperature (T)
         2) Pressure (P)
         3) Humidity (H)
      b. Other corrective factors
         1) Chamber exposure calibration factor (N_C) Cobalt-60 (^{60}Co)
         2) C_S (recombination loss)
         3) C_{St} (stem leakage)
         4) C_e (electron)
         5) C_λ (Photon)
         6) M (coulomb charge)
         7) Other

XII. Stereotactic

A. Theory of radiosurgery

B. Equipment
   1. Gamma knife
   2. Linear accelerator

C. Immobilization
   1. Head frame
      a. Relocatable
      b. Non-relocatable

D. Tumor localization and planning
   1. Computed tomography
   2. MRI and linear distortion effect
   3. Digitizing images and tumor outlines
   4. Entering isocenters and implications of isocenters with placement
   5. Beam shaping
   6. Treatment planning system requirements

E. Localizing isocenters
   1. Floor stand
   2. Couch mount
   3. Other

F. Treatment sites and doses
   1. Arterio-venous malformation (AVM)
   2. Meningiomas
   3. Glioblastomas
   4. Acoustic neuromas
   5. Other

G. Vital structures
   1. Optic nerves and chiasm
   2. Brain stem
   3. Other

H. Advantages and disadvantages
   1. Fractionation
   2. Stability
   3. Comparison to surgery

XIII. Emerging Technologies

A. 3-D conformal therapy
   1. Simulation
      a. Computed tomography
      b. Reconstructed radiographs
         1) Virtual
         2) Digitally

2. Treatment planning
    a. 3-D treatment planning system
        1) Coplanar treatment plans
        2) Noncoplanar treatment plans
    b. Beam's eye view (BEV)
    c. Plan optimization
    d. Volume analysis and dose volume histograms (DVH)
    e. MRI and CT image registration
3. Conformal treatment
    a. Treatment
        1) Dynamic computer controlled therapy
        2) Fixed blocked conformal
    b. Multi-leaf collimation
    c. Beam intensity modulation
    d. Dynamic wedging
4. Treatment verification and portal imaging

B. Multi-leaf collimators and 3-D conformal therapy

Quality Management

Course Description
Content is designed to establish a protocol for a quality management program that incorporates all operations and functions of a radiation therapy facility/service. The comprehensive nature of a quality management program will be presented, examined and discussed within the context of professional standards of care. The interrelatedness of accreditation, certification, licensure and service delivery standards will be demonstrated and discussed.

Course Objectives
At the completion of the content outline, the student must:

1. Analyze the components of quality measures in a quality management program.
2. Evaluate the purpose, function and member's role on a quality management team.
3. Assess the radiation therapist's role in a quality management program.
4. Distinguish between federal, state and institutional accreditation standards and reporting regulations for quality management.
5. Evaluate the outcomes for quality management in radiation oncology as they relate to patient care, education and research.
6. Evaluate the purpose, procedures and frequency for both manual and electronic treatment documentation and quality control.
7. Determine the areas of common error in treatment documentation.
8. Establish the procedure for assuring the quality of the records in the radiation oncology department, both manual and electronic.
9. Examine record and verify systems' purpose and function in quality management.
10. Examine the patient chart in terms of medical/legal issues.
11. Evaluate the significance of treatment documentation outcomes for patient care, education and research in radiation oncology.
12. Analyze the purpose and apply the procedures and frequency for determining appropriate conditions for the patient care areas in a radiation oncology department.
13. Evaluate the equipment and supplies necessary for quality operation of the patient care area.
14. Establish the procedures and frequency for evaluating the quality of the accessory devices used in radiation oncology.
15. Examine the purpose of accessory devices for radiation treatment delivery.
16. Differentiate between accessory devices that are used for patient immobilization and those used for beam modification.
17. Evaluate how the outcomes for patient care, education and research may be affected by the accessory devices.
18. Evaluate and apply the procedures and frequency for quality operation of the communication devices used in radiation oncology.
19. Analyze the purpose and appropriate operation for both visual and audio systems.
20. Examine the effects of communication devices on patient care, education and research.

21. Assess the purpose, function and appropriateness of computerized equipment for radiation treatment delivery and operation.
22. Evaluate aspects of the quality management, treatment delivery and documentation program that would benefit from computerization.
23. Evaluate different methods of computerized data collection.
24. Examine statistical reporting available through quality assurance computerization.
25. Establish quality measures necessary for computerized operation, data collection and reporting in radiation oncology.
26. Analyze the outcomes for patient care, education and research using computerization in the radiation oncology department.
27. Select the method, materials and frequency for determining quality equipment operation.
28. Analyze a treatment unit's sources of malfunction.
29. Distinguish between safe and hazardous equipment operation.
30. Select acceptable quality limits for operation.
31. Formulate a plan for emergency conditions.
32. Evaluate the outcomes for patient care, education and research as they relate to the operation and treatment delivery using treatment and simulation/localization units.
33. Establish the procedures and frequency for providing quality dosimetry/treatment plans.
34. Analyze the source of error, evaluating methods and material used for identification and determining the effect on treatment delivery, education and research.
35. Examine the quality assurance for data collection and transfer in medical dosimetry/treatment planning.
36. Analyze the purpose and establish procedures and frequency for quality outcomes of device fabrication.
37. Analyze the quality measures and their appropriateness necessary for device fabrication used in treatment delivery.
38. Evaluate the health and safety issues and testing necessary for the device fabrication.

Course Content

I. Introduction to the Principles of Quality Management

A. Definition and rationale for quality measures
   1. Quality control
   2. Quality assurance
   3. Quality improvement

B. Team approach

C. Radiation therapist's role

D. Accreditation standards
   1. Federal
   2. State
   3. Institutional

E. Reporting regulations

II. Treatment Documentation

A. Methods and materials

B. Common errors

C. Purpose, procedure and frequency of chart checking

D. Charting
   1. Manual
   2. Electronic

E. Record and verify

F. Medical/legal aspects of charting
   1. Mechanical parameters
   2. Personnel parameters

G. Portal imaging
   1. Manual
   2. Electronic

H. Corrective measures

I. Documentation

J. Outcomes
   1. Patient care
   2. Educational
   3. Research

III. General Conditions of Patient Care Area

A. Purpose, procedure and frequency of checks

B. Equipment and supplies

C. Corrective measures

D. Documentation

E. Outcomes
   1. Patient care
   2. Educational
   3. Research

IV. Accessory Devices

A. Purpose, procedures and frequency of checks

B. Immobilizers

C. Beam modifiers

D. Attachments

E. Corrective measures

F. Documentation

G. Outcomes
   1. Patient care
   2. Educational
   3. Research

V. Communication Devices

A. Purpose, procedure and frequency of checks

B. Visual systems

C. Audio systems

D. Corrective measures

E. Documentation

F. Outcomes
   1. Patient care
   2. Educational
   3. Research

VI. Computerization

A. Equipment

B. Data input

C. Data output or reporting

D. Corrective measures

E. Documentation

F. Outcomes
   1. Patient care
   2. Educational
   3. Research

VII. Treatment and Simulation/Localization Units

A. Control panel and indicator lights
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective measures
   6. Documentation
   7. Safety and hazards

B. Mechanical and electrical safety devices
   1. Mechanical
      a. Purpose, procedure and frequency
      b. Sources of malfunction
      c. Frequency
      d. Materials and methodology

2. Electrical
    a. Purpose, procedure and frequency
    b. Sources of malfunction
    c. Frequency
    d. Materials and methodology
3. Area radiation monitoring devices
    a. Purpose, procedure and frequency
    b. Sources of malfunction
    c. Frequency
    d. Materials and methodology
4. Planning for emergencies
5. Corrective measures
6. Documentation
7. Safety and hazards

C. Distance indicators
    1. Purpose, procedure and frequency
    2. Sources of malfunction
    3. Frequency
    4. Materials and methodology
    5. Corrective measures
    6. Documentation
    7. Safety and hazards

D. Light field, radiation field and collimator
    1. Purpose, procedure and frequency
    2. Sources of malfunction
    3. Frequency
    4. Materials and methodology
    5. Corrective measures
    6. Documentation
    7. Safety and hazards

E. Machine dose rate
    1. Purpose, procedure and frequency
    2. Sources of malfunction
    3. Frequency
    4. Corrective measures
    5. Materials and methodology
    6. Documentation
    7. Safety and hazards

F. Beam penetration quality
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards

G. Field symmetry and flatness
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards

H. Mechanical and optical patient alignment devices
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards

I. Linear scales on treatment tables
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards

J. Collimator rotation
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective measures
   6. Documentation
   7. Safety and hazards

K. Gantry rotation
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective measures
   6. Documentation
   7. Safety and hazards

L. Stability of isocenter under collimator and gantry rotation
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective measures
   6. Documentation
   7. Safety and hazards

M. Treatment couch isocenter
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective measures
   6. Documentation
   7. Safety and hazards

N. Film processor
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective Measures
   6. Documentation
   7. Safety and hazards

O. Quality measures

P. Outcomes
   1. Patient care
   2. Educational
   3. Research

VIII. Localization/Simulation Unit

A. Output
   1. X-ray tube
      a. Test material and equipment
      b. Test procedures
      c. Evaluation and interpretation
      d. Preventive maintenance
      e. Sources of malfunction
      f. Corrective measures
   2. Fluoroscope
      a. Test material and equipment
      b. Test procedures
      c. Evaluation and interpretation
      d. Preventive maintenance
      e. Sources of malfunction
      f. Corrective measures
   3. CT component of simulator
      a. Test material and equipment
      b. Test procedures
      c. Evaluation and interpretation
      d. Preventive maintenance
      e. Sources of malfunction
      f. Corrective measures
   4. Accessories (film, screens, grids, digital equipment)
      a. Preventative maintenance sources
      b. Malfunction
      c. Corrective measures
   5. Documentation
   6. Safety hazards

B. Outcomes
   1. Patient care
   2. Educational
   3. Research

IX. LDR, MDR and HDR Brachytherapy

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Materials and methodology

D. Safety and hazards

E. Corrective measures

F. Documentation

G. Outcomes
   1. Patient care
   2. Educational
   3. Research

X. Medical Dosimetry and Treatment Planning

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Data acquisition

D. Materials and methodology

E. Safety and hazards

F. Corrective measures

G. Documentation

H. Outcomes
   1. Patient care
   2. Educational
   3. Research

XI. Device Fabrication

A. Purpose, procedure and frequency of checks

B. Materials and methodology

C. Safety and hazards

D. Corrective measures

E. Documentation

F. Outcomes
   1. Patient care
   2. Educational
   3. Research

Clinical Practice

Course Description
Content and clinical practice experiences shall be designed for sequential development, application, analysis, integration, synthesis and evaluation of concepts and theories in radiation therapy. Through structured sequential assignments in clinical facilities, concepts of team practice, patient-centered clinical practice and professional development shall be discussed, examined and evaluated.

Clinical practice experiences shall be designed to provide care to the patient in the therapeutic setting for simulation, treatment planning and administration of a prescribed course of treatment. Levels of competency and outcomes measurement shall assure the well-being of the patient preparatory to, during and following delivery of radiation therapy treatment and services.

Course Outcomes
Within the curriculum model of the program, at the conclusion of structured sequential clinical practice learning experiences, the student will:

1. Assess, evaluate and formulate priorities in daily clinical practice.
2. Establish concepts of team practice that focus on organizational theories of goal setting, establishing priorities, leadership, roles of team members, variations in membership, role negotiation and conflict resolution.
3. Adapt to changes and new situations.
4. Establish patient-centered clinically effective service delivery strategies.
5. Implement and deliver a prescribed course of treatment adhering to acceptable departmental, institutional, governmental and professional standards.
6. Assess and evaluate the patient's status and condition to deliver a prescribed course of radiation therapy.
7. Synthesize the technologies and methodologies for treatment delivery.
8. Analyze, apply and demonstrate the principles of radiation protection standards.
9. Differentiate between tumor lethal dose and normal tissue tolerance dose.
10. Apply the principles of total quality management.
11. Detect equipment malfunctions and select appropriate action.
12. Construct/prepare immobilization, beam directional and beam modification devices.
13. Design, compare and contrast treatment plans.
14. Perform manual and computer dosimetric calculations.
15. Perform simulation and localization procedures.
16. Establish appropriate and effective written, oral and nonverbal communication with patient, family, the public and officials.
17. Demonstrate safe, ethical and legal practices.
18. Judge the clinical significance of the patient's personal beliefs and values for adaptation for the treatment plan.

19. Demonstrate awareness and operate within the radiation therapist scope of practice, regardless of personal beliefs and the appropriateness of the patient's treatment.
20. Assess and evaluate psychological and physical changes in the patient's condition and formulate appropriate actions.
21. Appraise cultural and age differences that influence patient compliance with treatment.
22. Differentiate gender, cultural, age and economic related factors that influence diagnosis, treatment and follow-up of patients with pathological illnesses.
23. Apply principles for transferring, positioning, immobilizing and restraining of patient.
24. Apply concepts of teaching and learning theories in design, implementation and evaluation in the education of patient, family, colleagues and the community.
25. Plan and implement programs designed to promote and maintain health and wellness.
26. Interact with the patient and family in a manner that provides the desired psychosocial support.
27. Interpret patient side effects and/or complications to create an interdisciplinary management strategy that fosters prevention, healing and comfort.
28. Document care in the patient's record.
29. Assess, evaluate and demonstrate life support procedures.
30. Demonstrate knowledge of the institution's procedures and respond to emergencies, disasters and accidents.
31. Distinguish the chain of command in emergencies, disasters and accidents.
32. Differentiate between emergency and non-emergency radiation therapy procedures.
33. Identify and respond to rapid physiological changes in the patient's condition.
34. Encompass strategies that assure professional development at a level of clinical practice consistent with acceptable standards.
35. Establish values and attitudes congruent with the profession's standards and ethics.
36. Provide radiation therapy services by contributing as an essential member of the radiation oncology treatment team through provision of total quality care of each patient undergoing a prescribed course of treatment.
37. Evaluate and assess treatment delivery components.
38. Provide radiation therapy treatment delivery services to cure or improve the quality of life of patients by accurately delivering a prescribed course of treatment.
39. Evaluate and assess daily the physiologic and psychological responsiveness of each patient to treatment delivery.
40. Maintain values congruent with the profession's code of ethics and scope of practice as well as adhering to national, institutional and/or departmental standards, policies and procedures regarding treatment delivery and patient care.

Published by

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American Society of
Radiologic Technologists

15000 Central Ave. SE, Albuquerque, NM 87123-3917
505-298-4500 • 800-444-2778 • Fax 505-298-5063
www.asrt.org