

# CLINICAL RADIATION SCIENCES, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN NUCLEAR MEDICINE TECHNOLOGY (SECOND MODALITY)

The department offers second modality B.S. degree concentrations for American Registry of Radiologic Technologists-certified radiographers who desire to continue their professional education and concentrate in radiation therapy, nuclear medicine technology or radiologist assistant. Upon meeting admission prerequisites, students complete a five-semester, full-time course of study including didactic, laboratory and clinical education. Graduates are eligible for additional national professional certification examinations.

## Learning outcomes

Upon completing this program, students will know and know how to do the following:

- Attain clinical competence in entry level nuclear medicine procedures
- Communicate effectively with patients, staff and physicians in the Nuclear Medicine department
- Demonstrate effective written communication
- Demonstrate critical thinking skills during their nuclear medicine clinical experience
- Demonstrate critical thinking skills in developing a research project
- Demonstrate professionalism during their nuclear medicine clinical experience

## Special requirements

### Prerequisites for Certificate/AAS degree holders

Course	Title	Hours
	ARRT certification (or eligibility) in radiography or radiation therapy <sup>1</sup>	
	Humanities course	3
	English composition course	3
	Social science course	3
	General chemistry (+labs)	8

### Prerequisites for AS/AA/AA&S/BS degree holders

Course	Title	Hours
	ARRT certification in radiography or radiation therapy (or eligibility) <sup>1</sup>	
	General Chemistry (+labs)	8
	Electives	2

<sup>1</sup>

Must be ARRT certified within two semesters of enrollment for eligibility.

## English proficiency

All non-native applicants must meet VCU's minimum TOEFL score requirements prior to admission.

Enrolled students must earn a minimum grade of C in the following CLRS courses:

Course	Title	Hours
CLRS 303	Orientation to Nuclear Medicine	2
CLRS 317	Nuclear Medicine Procedures I	3
CLRS 318	Nuclear Medicine Procedures II	2
CLRS 319	Nuclear Medicine Procedures III	3
CLRS 321	Nuclear Medicine Physics and Instrumentation I	2
CLRS 322	Nuclear Medicine Physics and Instrumentation II	3
CLRS 393	Clinical Education I	2-5
CLRS 394	Clinical Education II	2-4
CLRS 395	Clinical Education III	2-6
CLRS 417	Nuclear Medicine Procedures IV	3
CLRS 430	Radiobiology	2
CLRS 453	Quality Management in Nuclear Medicine	2
CLRS 493	Clinical Education IV	1-5
CLRS 494	Clinical Education V	1-5
CLRZ 321	Nuclear Medicine Physics and Instrumentation Laboratory I	1
CLRZ 322	Nuclear Medicine Physics and Instrumentation Laboratory II	1

Must complete statistics or meet requirements for STAT 210 prior to enrollment.

## Degree requirements for Clinical Radiation Sciences, Bachelor of Science (B.S.) with a concentration in nuclear medicine technology (second modality)

### Admission requirements (10<sup>1</sup> or 17<sup>2</sup> credits)

Course	Title	Hours
	English composition <sup>2</sup>	3
	Humanities <sup>2</sup>	3
	Social/behavioral science <sup>2</sup>	3
	Chemistry and labs equivalent to the following: <sup>1,2</sup>	8
	CHEM 101 & CHEZ 101 General Chemistry I and General Chemistry Laboratory I	
	CHEM 102 & CHEZ 102 General Chemistry II and General Chemistry Laboratory II	
	Electives <sup>1</sup>	2

<sup>1</sup>

Certificate/AAS degree holders

<sup>2</sup>

AS/AA/AA&S/BS degree holders

**Collateral requirements**

Course	Title	Hours
ARRT Radiography/Radiation Therapy certification		50
STAT 210	Basic Practice of Statistics	3
UNIV 200	Inquiry and the Craft of Argument	3
Total Hours		56

**Major requirements**

Course	Title	Hours
CLRS 206	Cross-sectional Anatomy	2
CLRS 303	Orientation to Nuclear Medicine	2
CLRS 317	Nuclear Medicine Procedures I	3
CLRS 318	Nuclear Medicine Procedures II	2
CLRS 319	Nuclear Medicine Procedures III	3
CLRS 321 & CLRZ 321	Nuclear Medicine Physics and Instrumentation I and Nuclear Medicine Physics and Instrumentation Laboratory I	3
CLRS 322 & CLRZ 322	Nuclear Medicine Physics and Instrumentation II and Nuclear Medicine Physics and Instrumentation Laboratory II	4
CLRS 390	Research Methods in the Radiologic Sciences (writing and academic research)	2
CLRS 393	Clinical Education I <sup>3</sup>	2
CLRS 394	Clinical Education II <sup>3</sup>	2
CLRS 395	Clinical Education III <sup>3</sup>	3
CLRS 398	Introduction to Research (writing and academic research)	1
CLRS 407	Introduction to PET/CT	2
CLRS 408	Introduction to Computed Tomography (CT)	2
CLRS 417	Nuclear Medicine Procedures IV	3
CLRS 430	Radiobiology	2
CLRS 453	Quality Management in Nuclear Medicine	2
CLRS 461 & CLRZ 461	Radiopharmaceutical: Preparation and Quality Control and Radiopharmacy Laboratory	3
CLRS 488	Senior Seminar	3
CLRS 493	Clinical Education IV <sup>3</sup>	3
CLRS 494	Clinical Education V <sup>3</sup>	3
CLRS 498	Senior Project	2
Total Hours		54

3

These courses have variable credits. The credits indicated are the most commonly used in the entry-level curriculum.

**Total minimum requirement 120 credits**

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

**Minimum credits from ARRT certification and courses from accredited college or university 60 credits****Junior year**

Fall semester		Hours
CLRS 303	Orientation to Nuclear Medicine	2
CLRS 317	Nuclear Medicine Procedures I	3
CLRS 321 & CLRZ 321	Nuclear Medicine Physics and Instrumentation I and Nuclear Medicine Physics and Instrumentation Laboratory I	3
CLRS 390	Research Methods in the Radiologic Sciences	2
CLRS 393	Clinical Education I	2
STAT 210	Basic Practice of Statistics	3
Term Hours:		15

**Spring semester**

CLRS 206	Cross-sectional Anatomy	2
CLRS 318	Nuclear Medicine Procedures II	2
CLRS 322 & CLRZ 322	Nuclear Medicine Physics and Instrumentation II and Nuclear Medicine Physics and Instrumentation Laboratory II	4
CLRS 394	Clinical Education II	2
CLRS 398	Introduction to Research	1
UNIV 200	Inquiry and the Craft of Argument	3
Term Hours:		14

**Summer semester**

CLRS 319	Nuclear Medicine Procedures III	3
CLRS 395	Clinical Education III	3
Term Hours:		6

**Senior year****Fall semester**

CLRS 408	Introduction to Computed Tomography (CT)	2
CLRS 417	Nuclear Medicine Procedures IV	3
CLRS 461 & CLRZ 461	Radiopharmaceutical: Preparation and Quality Control and Radiopharmacy Laboratory	3
CLRS 493	Clinical Education IV	3
CLRS 498	Senior Project	2
Term Hours:		13

**Spring semester**

CLRS 407	Introduction to PET/CT	2
CLRS 430	Radiobiology	2
CLRS 453	Quality Management in Nuclear Medicine	2
CLRS 488	Senior Seminar	3
CLRS 494	Clinical Education V	3
Term Hours:		12

Total Hours: 60

- Clinical radiation sciences (p. 3)
- Clinical radiation laboratory (p. 7)

## Clinical radiation sciences

### **CLRS 101. Introduction to Clinical Radiologic Sciences. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Presentation and discussion of the art and science of medical imaging and therapeutics. Radiography, nuclear medicine, radiation therapy, sonography and other radiologic technologies will be discussed in terms of career specialties within the profession.

### **CLRS 201. Radiographic Imaging and Exposure I. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 205. Corequisites: CLRS 232 and CLRZ 201. Introduction to radiographic equipment and the imaging process. Covers topics including equipment operation and manipulating radiation exposure to produce quality radiographs. Presents information that prepares students for clinical practice. Emphasizes clinical problem-solving as it relates to patient variables, pathology and technical exposure factors.

### **CLRS 203. Pathophysiology I. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Presentation of the principles of disease and an introduction to various conditions of illness involving body systems.

### **CLRS 204. Pathophysiology I and II. 3 Hours.**

Continuous courses; 3-3 lecture hours. 3-3 credits. Prerequisites: BIOL 205, PHIS 206 and PHIZ 206. Completion of CLRS 203 to enroll in CLRS 204. Presentation of the principles of disease and an introduction to various conditions of illness involving body systems.

### **CLRS 205. Exploring Radiologic Sciences. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. A general overview of the wide variety of imaging and treatment modalities in radiologic sciences will be presented. Emphasis will be on understanding how these modalities are utilized in today's complex health care environment, as well as the role of the technologist/therapist.

### **CLRS 206. Cross-sectional Anatomy. 2 Hours.**

Semester course; 4 laboratory hours. 2 credits. Prerequisite: permission of instructor. A general overview of cross-sectional anatomy at representative levels will be presented. Emphasis will be on identifying major muscles, organs, bones and vessels on diagrams, photographs and images.

### **CLRS 208. Foundations of Patient Care. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours. 4 credits. Legal, ethical and technical foundations of patient care will be explored with emphasis on the application of these principles to common radiologic situations.

### **CLRS 211. Radiographic Procedures I. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: CLRS 208 with a minimum grade of C. Combines the study of anatomy and physiology and positioning for diagnostic radiographic examinations of the upper extremity, thorax, abdomen, lower extremity, spine and pelvis. Requires demonstration of competence in radiographic procedures, including positioning of simulated patients, manipulation of radiographic equipment and evaluation of radiographs.

### **CLRS 212. Radiographic Procedures II. 2 Hours.**

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisite: CLRS 211 with a minimum grade of C. Continuation of CLRS 211 with emphasis on anatomy and physiology and positioning for diagnostic radiographic examinations of routine contrast studies and basic headwork. Requires students to demonstrate competence in radiographic procedures, including positioning of simulated patients, manipulation of radiographic equipment and evaluation of radiographs.

### **CLRS 232. Radiation Safety. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Provides an overview of radiation protection as it applies to the radiation sciences. Emphasizes radiation sources, detection and regulations. Discusses radiation protection responsibilities of the radiologic technologist for patients, personnel and the public.

### **CLRS 294. Introduction to Clinical Education I. 0.5 Hours.**

Semester course; 60 clinical hours. 0.5 credit. Prerequisite: CLRS 208 with a minimum grade of C. Introduction to clinical experience supervised by clinical faculty and affiliate facility staff. Introduces students to the clinical process and equipment, and provides practical experience in routine, basic procedures.

### **CLRS 295. Introduction to Clinical Education II. 1 Hour.**

Semester course; 120 clinical hours. 1 credit. Prerequisites: CLRS 201, 211, 232 and 294 with a minimum grade of C in all. Continued introduction to clinical experience supervised by clinical faculty and affiliate facility staff. Provides additional practical experience in routine, basic procedures.

### **CLRS 300. Introduction to Sonography. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. This course is restricted to students in the clinical radiation sciences program. Introduces sonography as a career to include ultrasound equipment operation, sonography safety, legal and ethical issues, ultrasound image orientation and interpretation, professional organizations, and employment opportunities.

### **CLRS 301. Sonography Physics and Instrumentation I. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Enrollment restricted to clinical radiation sciences majors. Introduces ultrasound instrumentation, propagation principles and interactions to include, but not limited to, sound waves, interaction of sound with different mediums, transducer design, display modes, sound beams, resolution, ultrasound equipment function, 2-D and real-time imaging.

### **CLRS 302. Sonography Physics and Instrumentation II. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 301. Enrollment restricted to clinical radiation science majors. Expands upon discussion of material introduced in prerequisite course along with implementing ultrasound instrumentation, propagation principles and interactions. Introduces new concepts such as sound waves, image processing, hemodynamics, Doppler, ultrasound artifacts and quality assurance.

### **CLRS 303. Orientation to Nuclear Medicine. 2 Hours.**

Semester course; 1 lecture and 2 clinical hours. 2 credits. Prerequisites: CLRS 208 and CLRS 232 both with a minimum grade of C. Designed to acquaint the student with the field of nuclear medicine in general and the Program in Nuclear Medicine Technology in particular. It also provides an introduction to clinical practice.

### **CLRS 305. Orientation to Radiation Therapy. 2 Hours.**

Semester course; 1 lecture and 2 laboratory hours. 2 credits. Prerequisites: CLRS 208 and CLRS 232, both with a minimum grade of C. Introduction to the clinical process, equipment and history of radiation therapy. Information will be presented that prepares the student to begin clinical practice. Clinical rotations and lab exercises are designed to expose the student to various aspects of radiation therapy.

**CLRS 309. Oncologic Patient Care. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisite: CLRS 208 with a minimum grade of C. Pre- or corequisite: CLRS 305. Covers the basic concepts of patient care specific to radiation therapy, including consideration of physical and psychological conditions. Patient interactions, patient examinations, asepsis, local and systemic reactions, nutrition and medications are discussed. Factors influencing patient health during and following a course of radiation will be identified.

**CLRS 311. Abdominal Sonography. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisite: CLRS 301. Enrollment restricted to clinical radiation science majors. Investigates cross-sectional anatomy, pathology, image production/interpretation and sonography scanning techniques/protocols related to abdominal sonography and small parts.

**CLRS 312. Radiographic Procedures III. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisite: CLRS 212 with a minimum grade of C. Continuation of CLRS 211 and 212 to cover additional and alternative positions for routine radiographic examinations as well as special studies of circulatory, reproductive, urinary, skeletal and central nervous systems. Discusses equipment, procedures and strategies for performing pediatric, trauma, mobile and operating room radiographic exams. Includes small group simulation opportunities.

**CLRS 314. Pathology and Treatment Principles I. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisites: CLRS 309 and CLRS 323 with a minimum grade of C in both. Presents the fundamentals of the disease processes for cancer of the following: skin, thorax, genitourinary, gynecological, head and neck, central nervous system, and breast. Discusses malignant condition, etiology and epidemiology, patient workup, and methods of treatment. Attention to patient prognosis, treatment results and the effects of combined therapies. Requires demonstration of competence in selected radiotherapeutic procedures, including positioning of simulated patients and the manipulation of equipment.

**CLRS 317. Nuclear Medicine Procedures I. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: two semesters of general chemistry. Pre- or corequisite: CLRS 303. Presents the techniques employed in the performance of routine nuclear medicine procedures. Topics include anatomy and physiology, pathology, patient preparation, contraindications, radiopharmaceuticals, dose route of administration, biodistribution, imaging protocols, equipment setup, and common findings.

**CLRS 318. Nuclear Medicine Procedures II. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisite: CLRS 317 with a minimum grade of C. Presents the techniques employed in the performance of routine nuclear medicine procedures. Topics include anatomy and physiology, pathology, patient preparation, contraindications, radiopharmaceuticals, dose route of administration, biodistribution, imaging protocols, equipment setup, and common findings.

**CLRS 319. Nuclear Medicine Procedures III. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 318 with a minimum grade of C. Presents the techniques employed in the performance of routine nuclear medicine procedures. Topics include anatomy and physiology, pathology, patient preparation, contraindications, radiopharmaceuticals, dose route of administration, biodistribution, imaging protocols, equipment setup, and common findings.

**CLRS 320. Radiographic Imaging and Exposure II. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CLRS 201 and CLRZ 201 both with a minimum grade of C. Emphasizes federal regulations and monitoring of the imaging system components that may affect radiographic quality through improper functioning. Provides in-depth exploration of digital imaging.

**CLRS 321. Nuclear Medicine Physics and Instrumentation I. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Pre- or corequisite: CLRS 303. Corequisite: CLRZ 321. Presents the physical principles of atomic structure, electromagnetic spectrum, units of measurement, radioactive decay and attenuation in matter. Operation of radiation equipment will include statistical applications and quality control procedures.

**CLRS 322. Nuclear Medicine Physics and Instrumentation II. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CLRS 317, CLRS 321 and CLRZ 321 with a minimum grade of C in all. Corequisite: CLRZ 322. Presents advanced applications in physics and the operating principles of nuclear medicine imaging devices and related quality control procedures.

**CLRS 323. Radiation Therapy, Techniques and Applications. 4 Hours.**

Semester course; 4 lecture hours. 4 credits. Pre- or corequisite: CLRS 305. Presents the basic concepts of dosimetry and treatment planning. Various external beam techniques and applications, depth dose data and summation of isodose curves are discussed. Modalities of treatment, patient setup, dose measurement and verification also are included.

**CLRS 325. Sonography Professional Seminar. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CLRS 311 and CLRS 329. Enrollment restricted to clinical radiation science majors. Integrates various didactic and clinical concepts as they relate to the professional practice of diagnostic medical sonography.

**CLRS 329. Obstetric and Gynecologic Sonography. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisite: CLRS 302. Enrollment restricted to clinical radiation science majors. Introduces female and fetal cross-sectional anatomy, pathology, image production and interpretation, and scanning techniques/protocols related to obstetric and gynecologic sonography.

**CLRS 331. Radiographic Imaging Equipment. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 320 with a minimum grade of C. Presents the principles and operation of general and specialized X-ray equipment. Emphasizes the equipment necessary to perform radiographic, fluoroscopic and tomographic examinations.

**CLRS 332. Radiographic Pathology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CLRS 204 and CLRS 393 with a minimum grade of C or permission of instructor. Provides introduction to the study of radiographic pathology through reading and observation of film interpretation. Emphasizes recognition of common disease processes as demonstrated radiographically and, via advanced imaging modalities; where appropriate, understanding how to vary positioning and techniques to produce optimally diagnostic images; and the role of different imaging modalities in the evaluation of disease.

**CLRS 341. Radiation Physics. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: PHYS 101, PHYZ 101 or PHYS 201 and CLRS 232 with a minimum grade of C. Discusses fundamentals of the atom, electricity and magnetism. Emphasizes the production of X- and gamma rays, and the interaction of radiation with matter.



**CLRS 342. Physics for Radiation Therapy. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CLRS 323 and CLRS 341 with a minimum grade of C in both. Includes a discussion of the properties of electromagnetic and particulate radiation. Details of production, interactions, treatment units, measurement of radiation, radioactivity and brachytherapy are presented.

**CLRS 390. Research Methods in the Radiologic Sciences. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: STAT 210 and junior standing or permission of instructor. The fundamentals of the research process will be presented for analysis and discussion. Elements of research appropriate to the radiologic sciences will be reviewed. Emphasis will be on the ability to critically review research studies along with the selection and design of a research project.

**CLRS 393. Clinical Education I. 2-5 Hours.**

Semester course; 2-5 clinical hours. 2-5 credits (120 contact hours per credit). Prerequisites: CLRS 208 with a minimum grade of C; and CLRS 201, CLRS 303 or CLRS 305 with a minimum grade of C. Clinical experience supervised by clinical faculty and affiliate facility staff. Students gain practical experience in routine, basic procedures and observe more advanced procedures.

**CLRS 394. Clinical Education II. 2-4 Hours.**

Semester course; variable clinical hours (120 hours per credit). 2-4 credits. Prerequisite: CLRS 393 with a minimum grade of C. Clinical experience supervised by clinical faculty and affiliate facility staff. Students gain practical experience in routine, basic procedures and observe more advanced procedures.

**CLRS 395. Clinical Education III. 2-6 Hours.**

Semester course; variable clinical hours (120 hours per credit). 2-6 credits. Prerequisite: CLRS 394 with a minimum grade of C. Clinical experience supervised by clinical faculty and affiliate facility staff. Students gain additional practical experience in routine as well as advanced procedures.

**CLRS 398. Introduction to Research. 1 Hour.**

Semester course; 1 credit. Prerequisite: CLRS 390. Provides students the opportunity to explore and investigate a topic of special interest in their area of concentration under the supervision of a faculty adviser. Emphasizes the application of research concepts to writing a research project proposal.

**CLRS 400. Contemporary Topics in Radiologic Sciences. 4 Hours.**

Semester course; 4 lecture hours. 4 credits. Enrollment restricted to clinical radiation sciences majors with junior standing or higher. Introduces issues and concepts relevant to the radiologic sciences such as leadership, professionalism, emerging technologies, and ethics and law. Applies advanced topical areas to both general radiologic sciences and individual professional concentrations.

**CLRS 401. Pediatric Sonography. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisite: CLRS 311. Enrollment restricted to clinical radiation science majors. Investigates anatomy, pathology, image production/interpretation and ultrasound scanning techniques/protocols specific to pediatric ultrasound imaging. Examines anatomical areas such as the pediatric bowel, spine, hips and head/brain.

**CLRS 403. Advanced Patient Care for the Imaging Professional. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CLRS 208 with a minimum grade of C and junior standing or permission of instructor. Explores advanced patient care techniques and age-specific considerations in the radiation sciences. Emphasizes the application of advanced patient care principles.

**CLRS 404. Ultrasound Pathology and Preliminary Writing. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: CLRS 311 and CLRS 329. Enrollment restricted to clinical radiation science majors. Introduces case studies pertaining to the ultrasonic evaluation of small parts, abdominal organs, pelvic anatomy and obstetrics to increase and assesses the critical-thinking skills needed to proficiently write preliminary ultrasound reports.

**CLRS 405. Principles of Mammography. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: CLRS 201 and CLRS 320 with a minimum grade of C in both and senior standing or permission of instructor. Presentations and discussions designed to provide an overview of the principles of mammography. Topics include history, anatomy, physiology and pathology of the breast; exposure techniques; and quality control. Focuses on routine and specialized positioning of the breast and image evaluation to prepare students for practical experience in mammography.

**CLRS 406. Introduction to MRI. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 341 with a minimum grade of C or permission of instructor. An introduction to the elements of magnetic resonance imaging, including instrumentation, physical principles, image production and quality, MR safety, magnetic resonance angiography and imaging applications.

**CLRS 407. Introduction to PET/CT. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisite: CLRS 408. Overview of PET and PET/CT focusing on instrumentation, radiopharmaceuticals and its diagnostic application in neurology, oncology and cardiology.

**CLRS 408. Introduction to Computed Tomography (CT). 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisite: CLRS 341 with a minimum grade of C or permission of instructor. Provides the student with an overview of computed tomography. Topics include computed tomography physical principles, data acquisition/image reconstruction, equipment and terminology. Patient care issues (i.e., preparation, monitoring) and basic quality control will be introduced.

**CLRS 410. Routine Computed Tomography Procedures. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Prerequisites: CLRS 206 and 408, or permission of instructor. Presents routine procedures used in computed tomography imaging. Reviews examinations and protocols involving the head, chest, abdomen and extremities.

**CLRS 412. Radiation Therapy Treatment Planning. 3 Hours.**

Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisites: CLRS 323 and CLRS 342 with a minimum grade of C in both or permission of instructor. An introduction to routine 2-D and 3-D treatment planning for the most common forms of cancer including prostate, rectum, lung, breast, and head and neck regions. Simulated lab training using a treatment planning system will be included. Emphasis will be on the rationale and process of treatment planning for patients undergoing radiation therapy.

**CLRS 415. Pathology and Treatment Principles II. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisite: CLRS 314 with a minimum grade of C. A continuation of CLRS 314. Presents the fundamentals of the disease process for the following cancers: gastrointestinal, lymphomas and hematological malignancies, bone tumors, childhood tumors, and eye and orbital tumors. Discusses patient workup and prognosis, treatment results, and the effects of combined therapies. Radiotherapeutic emergencies, palliation and combined modality treatment also will be discussed. Emphasis will be placed on traditional and advanced technology and its applications in treatment delivery in radiation oncology. Requires demonstration of competence in selected radiotherapeutic procedures, including positioning of simulated patients and the manipulation of equipment.

**CLRS 417. Nuclear Medicine Procedures IV. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 319 with a minimum grade of C. Presents the techniques employed in the performance of advanced nuclear medicine procedures. Topics include anatomy and physiology, pathology, patient preparation, contraindications, radiopharmaceuticals, dose route of administration, biodistribution, imaging protocols, equipment setup, and common findings.

**CLRS 420. Introduction to Vascular-Interventional Radiology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: departmental approval. Introduction to the basic techniques of vascular and interventional radiologic procedures with emphasis on the anatomy demonstrated, equipment, contrast agents, and the role and responsibilities of the technologist.

**CLRS 421. Vascular-Interventional Radiology Procedures. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 420. Enrollment restricted to clinical radiation science majors or by permission of department chair. Presents an overview of common vascular-interventional radiology procedures to include arteriography (abdominal, peripheral, pulmonary, cardiac and carotid/cerebral) as well as vascular and nonvascular interventions (filter placement, embolization, venous access and management of fluid collection, urinary disease and biliary disease). Emphasis is placed on instrumental, technique and imaging parameters.

**CLRS 430. Radiobiology. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: CLRS 232 with a minimum grade of C and senior standing or permission of instructor. Presents the principles of biologic responses to radiation, including factors influencing radiation effects, tissue sensitivity and tolerance. Clinical application in radiography, nuclear medicine and radiation therapy are reviewed.

**CLRS 453. Quality Management in Nuclear Medicine. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: CLRS 322 and CLRZ 322 with a minimum grade of C in both. Explores the quality assurance parameters in a nuclear medicine department. Emphasis is given to the performance of tests to assess survey meters, spectrometers, dose calibrators, gamma cameras and SPECT imaging systems. Additionally, quality assurance is discussed in terms of radiopharmaceuticals, radioimmunoassay laboratories and patient management.

**CLRS 455. Quality Management in Radiation Therapy. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: CLRS 323 and CLRS 342 with a minimum grade of C. Designed to provide the student with knowledge of the concepts and principles of quality assurance. The performance of various tests including purpose, sources of malfunction and action guidelines will be discussed.

**CLRS 461. Radiopharmaceutical: Preparation and Quality Control. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: CLRS 319, CLRS 322 and CLRZ 322, all with a minimum grade of C. Provides the technical knowledge necessary for the preparation and quality control of radiopharmaceutical agents for in-vivo and in-vitro nuclear medicine studies.

**CLRS 471. Radiology Imaging Procedures for Radiologist Assistants I and II. 3 Hours.**

Continuous courses; 3-3 lecture hours. 3-3 credits. Prerequisites: CLRS 332, CLRS 403, CLRZ 403 and permission of instructor. Completion of CLRS 471 to enroll in CLRS 472. Establishes a framework for radiologist assistants' participation in patient examinations for diagnostic inspection and/or therapeutic treatment. Emphasizes establishment of fundamental radiology procedures that follow American College of Radiology Standards for principles and practices producing high-quality radiographic care. Includes basic radiology procedures in genitourinary, gastrointestinal, pediatric, thoracic, musculoskeletal selections and vascular/interventional specialties. Addresses legal, ethical and professional issues concerning radiologist assistants.

**CLRS 472. Radiology Imaging Procedures for Radiologist Assistants I and II. 3 Hours.**

Continuous courses; 3-3 lecture hours. 3-3 credits. Prerequisites: CLRS 332, CLRS 403, CLRZ 403 and permission of instructor. Completion of CLRS 471 to enroll in CLRS 472. Establishes a framework for radiologist assistants' participation in patient examinations for diagnostic inspection and/or therapeutic treatment. Emphasizes establishment of fundamental radiology procedures that follow American College of Radiology Standards for principles and practices producing high-quality radiographic care. Includes basic radiology procedures in genitourinary, gastrointestinal, pediatric, thoracic, musculoskeletal selections and vascular/interventional specialties. Addresses legal, ethical and professional issues concerning radiologist assistants.

**CLRS 475. Medical Imaging Fundamentals for Radiologist Assistants. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CLRS 332, CLRS 403, CLRZ 403 and permission of instructor. Promotes an understanding of methods and techniques for the systematic observation of static and dynamic diagnostic images for the purpose of evaluating the presence of abnormalities, anomalies and pathological conditions. Includes protocols for drafting memoranda of initial observations based on image assessment.

**CLRS 480. Applied Radiology Management. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: departmental approval. Relates basic concepts in management to the radiologic environment and explores the relationship between the radiologic facility and the health care system.

**CLRS 481. Applied Pharmacology for Radiologic Sciences. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Enrollment restricted to clinical radiation science majors. Covers general pharmacology including the study of drug groups, dosages, administrations and reactions of drugs common to patients. Special emphasis on contrast media and other agents commonly used in medical imaging and therapy.

**CLRS 488. Senior Seminar. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: senior standing in department. Designed to allow students to integrate the various individual courses into a single perspective as it relates to the radiation sciences. Addresses timely professional issues, including the need for lifelong learning and participation in professional organizations, as well as preparing for certification and future employment.

**CLRS 492. Directed Study: Radiologic Sciences. 1-4 Hours.**

Semester course; 1-4 independent study hours. 1-4 credits. A maximum of 6 credits can apply toward graduation requirements. Enrollment restricted to clinical radiation science majors. Provides the opportunity for individualized research projects, tutorial studies, special clinical work or other topics not available in formal course work.

**CLRS 493. Clinical Education IV. 1-5 Hours.**

Semester course; variable clinical hours (120 hours per credit). 1-5 credits. Prerequisite: CLRS 395 with a minimum grade of C. Clinical experience supervised by clinical faculty and affiliate facility staff. Students gain additional practical experience in routine, basic and advanced procedures.

**CLRS 494. Clinical Education V. 1-5 Hours.**

Semester course; variable clinical hours (120 hours per credit). 1-5 credits. Prerequisite: CLRS 493 with a minimum grade of C. Clinical experience supervised by clinical faculty and affiliate facility staff. Students gain additional practical experience in routine, basic and advanced procedures.

**CLRS 498. Senior Project. 2 Hours.**

Semester course; 2 seminar hours. 2 credits. Prerequisites: CLRS 390, CLRS 398 and senior standing in department. Emphasizes the application of research concepts in the design, implementation and presentation of a project under the supervision of a faculty adviser. Students investigate a topic of interest in their area of concentration.

## Clinical radiation laboratory

**CLRZ 201. Radiographic Imaging and Exposure I Laboratory. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Prerequisite: CLRS 205. Pre- or corequisite: CLRS 201. Designed to introduce students to the fundamentals of radiographic image production. Requires performance of laboratory exercises to become familiar with equipment operation and manipulate radiation exposure variables to produce quality images.

**CLRZ 321. Nuclear Medicine Physics and Instrumentation Laboratory I. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Pre- or corequisite: CLRS 303. Corequisite: CLRS 321. Presentation of the applications and techniques employed in the operation of nuclear medicine non-imaging devices. Labs will emphasize the use of survey meters, dose calibrator and scintillation counting device.

**CLRZ 322. Nuclear Medicine Physics and Instrumentation Laboratory II. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Prerequisites: CLRS 321 and CLRZ 321 with a minimum grade of C in both. Corequisite: CLRS 322. Evaluation of applications of different imaging techniques and computer processing utilized in nuclear medicine. Emphasizes the use of single and multiple channel analyzers, planar and SPECT acquisition, and image processing.

**CLRZ 403. Advanced Patient Care for the Imaging Professional. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Prerequisite: CLRS 208 or permission of instructor. Pre- or corequisite: CLRS 403. This course provides simulated experience in performing advanced patient care techniques related to the radiation sciences. Topics include cardiac rhythm interpretation, advanced cardiac life support, urinary catheterization, tracheostomy care, basic laboratory skills, basic respiratory therapy skills, pulse oximetry, IV therapy and pharmacology, and conscious sedation.

**CLRZ 405. Principles of Mammography Lab. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Prerequisites: CLRS 201 and CLRS 320, or permission of instructor. Pre- or corequisite: CLRS 405. Provides simulated experience in performing positioning of the breast. Students will be expected to demonstrate competence in positioning the breast phantom for a variety of routine and specialized projections. In addition, quality control procedures specific to mammography will be performed.

**CLRZ 461. Radiopharmacy Laboratory. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Prerequisites: CLRS 319, CLRS 322 and CLRZ 322, all with a minimum grade of C. A simulated radiopharmacy laboratory will focus on operation of laboratory equipment in the compounding of radiopharmaceuticals.