

CLINICAL RADIATION SCIENCES, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN NUCLEAR MEDICINE TECHNOLOGY (DEGREE COMPLETION)

Full- or part-time opportunities to complete a baccalaureate degree are offered for technologists or therapists certified by the American Registry of Radiologic Technologists, Nuclear Medicine Technology Certification Board and/or American Registry of Diagnostic Medical Sonography. In addition to general education and professional course work, the student selects electives from a wide variety of courses, allowing the design of a program that best meets the goals and interests of the individual.

Student learning outcomes

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

- Demonstrate effective written communication
- Demonstrate critical-thinking skills in developing a research project

Special requirements

Prerequisites

NMTCB/ARRT Certification (or eligibility) in nuclear medicine¹

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Must be NMTCB/ARRT certified within two semesters of enrollment.

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 CLRS 430.

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

Course	Title	Hours
General education (http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/)		
Select 12-13 credits from general education foundations and 17-18 credits from areas of inquiry. ¹		30
Major requirements		
• Major core requirements		
CLRS 206	Cross-sectional Anatomy	2
CLRS 398	Introduction to Research	1
CLRS 498	Senior Project	2
• Additional major requirements		

ALHP 430	Overview of Research in the Health Professions	3
CLRS 407	Introduction to PET/CT	2
CLRS 408	Introduction to Computed Tomography (CT)	2
CLRS 430	Radiobiology	2
Ancillary requirements		
NMTCB/ARRT nuclear medicine certification		50
HCMG 300	Health Care Organization and Services	3
STAT 210	Basic Practice of Statistics	3
Electives (300 level or higher)		34
Open electives		
Select any course		16
Total Hours		120

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Some general education categories will be met with admission requirements. Consult with an adviser to determine remaining categories.

The minimum number of credit hours required for this degree is 120.

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.

Sample outline (full-time option)

Credits toward admission for NMTCB/ARRT nuclear medicine certification: 50

Year one

Fall semester	Hours
ALHP 430 Overview of Research in the Health Professions	3
HCMG 300 Health Care Organization and Services	3
STAT 210 Basic Practice of Statistics	3
Natural/physical science elective	3
Social science elective	3
Term Hours:	15

Spring semester

CLRS 206 Cross-sectional Anatomy	2
CLRS 398 Introduction to Research	1
CLRS 430 Radiobiology	2
Electives	7
Humanities elective	3
Term Hours:	15

Summer semester

Electives (300-level +)	10
Term Hours:	10

Year two

Fall semester	Hours
CLRS 408 Introduction to Computed Tomography (CT)	2
CLRS 498 Senior Project	2
Electives (300-level +)	12
Term Hours:	16

Spring semester

CLRS 407	Introduction to PET/CT	2
Electives (300-level +)		12
Term Hours:		14
Total Hours:		70

The minimum number of credit hours required for this degree is 120.

Sample outline (part-time option)

Credits toward admission for NMTCB/ARRT nuclear medicine certification: 50

Year one

Fall semester		Hours
HCMG 300	Health Care Organization and Services	3
Natural/physical sciences elective		3
Term Hours:		6

Spring semester

CLRS 206	Cross-sectional Anatomy	2
STAT 210	Basic Practice of Statistics	3
Social science elective		3
Term Hours:		8

Summer semester

Elective		3
Term Hours:		3

Year two

Fall semester		Hours
ALHP 430	Overview of Research in the Health Professions	3
Elective		2
Humanities elective		3
Term Hours:		8

Spring semester

CLRS 398	Introduction to Research	1
CLRS 430	Radiobiology	2
Elective		2
Term Hours:		5

Summer semester

Electives (300-level +)		4
Term Hours:		4

Year three

Fall semester		Hours
CLRS 408	Introduction to Computed Tomography (CT)	2
CLRS 498	Senior Project	2
Electives (300-level +)		6
Term Hours:		10

Spring semester

CLRS 407	Introduction to PET/CT	2
Electives (300-level +)		6
Term Hours:		8

Summer semester

Electives (300-level +)		6
Term Hours:		6

Year four

Fall semester

Electives (300-level +)		6
Term Hours:		6

Spring semester

Electives (300-level +)		6
Term Hours:		6
Total Hours:		70

The minimum number of credit hours required for this degree is 120.

- Clinical radiation sciences (p. 2)
- Clinical radiation sciences 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 I. 4 Hours.

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

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 313. Abdominal Sonography II. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 311. Enrollment is restricted to clinical radiation science majors. Investigates cross-sectional anatomy, pathology, image production/interpretation and sonography scanning techniques/protocols related to abdominal sonography, breast and small parts.

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 316. Introduction to Vascular Sonography. 3 Hours.

Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisite: CLRS 302 or permission of the department chair. Enrollment is restricted to clinical radiation sciences majors or by permission of the department chair. Introduces basic anatomy, pathology and evaluation techniques of basic vascular anatomy, including venous, extracranial cerebrovascular and visceral vascular anatomy. Presents processes for performing venous, extracranial and visceral vascular protocols.

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 I. 3 Hours.

Semester course; 2 lecture and 2 laboratory hours. 3 credits. Enrollment is restricted to clinical radiation science majors. Introduces female cross-sectional anatomy, pathology, image production and interpretation, and scanning techniques/protocols related to basic 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 339. Obstetric and Gynecologic Sonography II. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: CLRS 329. Enrollment is restricted to clinical radiation science majors. Introduces maternal and fetal pathology, including fetal congenital abnormalities, placental and umbilical cord anomalies, and fetal neural, thoracic, cardiac, abdominal, urogenital and skeletal abnormalities. Image interpretation and scanning techniques/protocols related to obstetric sonography are discussed.

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 300, 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 416. Advanced Vascular Sonography. 3 Hours.

Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisite: CLRS 302 or permission of the department chair. Enrollment is restricted to clinical radiation sciences majors or by permission of the department chair. Introduces advanced anatomy, pathology and evaluation techniques of vascular anatomy, including arterial, intracranial cerebrovascular, dialysis grafts and visceral vascular anatomy. Presents processes for performing arterial, transcranial Doppler, dialysis mapping, and visceral vascular protocols and physiologic testing.

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 450. Musculoskeletal Sonography. 3 Hours.

Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisite: CLRS 302 or permission of the department chair. Enrollment is restricted to clinical radiation sciences majors or by permission of the department chair. Introduces musculoskeletal anatomy, pathology, image production and interpretation, and scanning techniques/protocols related to musculoskeletal sonography to include, but not limited to, the following joints: shoulder, elbow, hand/wrist, hip, knee, ankle/foot.

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 sciences 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.