HORRY GEORGETOWN TECHNICAL COLLEGE

INSTRUCTIONAL PACKAGE

RAD 145

Computed Tomography Physics and Instrumentation

202310
Fall 2023

INSTRUCTIONAL PACKAGE

Part I: Course Information

Effective Term: 202310

COURSE PREFIX: RAD 145 COURSE TITLE: Computed Tomography Physics and Instrumentation

CONTACT HOURS: 3-0-3 CREDIT HOURS: 3-0-3

RATIONALE FOR THE COURSE:

This course will provide the Computed Tomography student with physics, instrumentation and applications used in Computed Tomography. Quality control of CT equipment will be explored. Patient radiation dosage will be determined and minimized by the technologist using radiation safety precautions. New technological advances as multi-slice and multi-beam CT scanning will be explored

COURSE DESCRIPTION:

This course is a study of computed tomography physics and instrumentation. The course provides an overview of technology, application, and practice that is unique to the computed tomography profession

PREREQUISITES/CO-REQUISITES: RAD 103, RAD 135, RAD 140, RAD 120, and AHS 206

***Online/Hybrid** courses require students to complete the DLi Orientation Video prior to enrolling in an online course.

REQUIRED MATERIALS:

Please visit the BOOKSTORE online site for most current textbook information. Use the direct link below to find textbooks. Textbook is Required.

Computed Tomography: Physical Principles, Clinical Applications, and Quality Control- 4th Ed
Euclid Seeram
ISBN- 032331288 ISBN-13- 978-0323312882

Enter the semester, course prefix, number and section when prompted and you will be linked to the correct textbook.

TECHNICAL REQUIREMENTS:

Access to Desire2Learn (D2L), HGTC's learning management system (LMS) used for course materials.
Access to myHGTC portal for student self-services.
College email access – this is the college's primary official form of communication.

STUDENT IDENTIFICATION VERIFICATION:

Students enrolled in online courses will be required to participate in a minimum of one (1) proctored assignment and/or one (1) virtual event to support student identification verification. Please refer to your Instructor Information Sheet for information regarding this requirement.

NETIQUETTE: is the term commonly used to refer to conventions adopted by Internet users on the web, mailing lists, public forums, and in live chat focused on online communications etiquette. For more information regarding Netiquette expectations for distance learning courses, please visit Online Netiquette.

Part II: Student Learning Outcomes

COURSE LEARNING OUTCOMES and ASSESSMENTS*:

Week 1- Chapter 1 – Computed Tomography- An Overview

1. State the meaning of the following terms: transverse axial tomography, image reconstruction from projections.
2. State terms synonymous with CT number
3. Outline three steps that constitute the CT process.
4. Identify major components of a CT scanner and briefly explain how a CT scanner works.
5. Trace the significant developments in the history of CT including the contributions of Hounsfield and Cormac
6. Identify the essential elements of a digital imaging system.
7. Identify several applications of volume CT scanning
8. Identify major technology trends in CT technology.
9. Identify several features of CT product data.
10. State the meaning of digital image processing.

Week 2- Chapter 2- Digital Image Processing

1. Trace the history of digital imaging processing.
2. Describe the key elements of image formation and image representation.
3. Define each of the following: objects, images, analog image, digital image, digital image processing.
4. Describe the following three steps in image digitization: scanning, sampling, quantization.
5. Explain how an analog to digital converter works and describe the characteristics of speed and accuracy.
6. List the advantages of digitizing images.
7. List 4 image processing operations and explain how each works
8. Briefly explain each of the following: gray level mapping, look up table, histogram, spatial frequency filtering.
9. List two ways to perform spatial frequency filtering and outlined the basics of the convolution technique.
10. Draw and label the components of a generic digital image processing system.

11. Describe the similarities between digital image processing NCT as a digital image processing system.
12. List major image processing operations used in different medical imaging modalities.
13. State the reason why image processing is an essential tool for CT technologist.

Week 3- Chapter 3- Physical Principles of CT

1. State the shortcomings of radiography and tomography and explain how these limitations are over calm by CT.
2. State what is meant by the term data acquisition and briefly explain two methods of data acquisition.
3. Explain the meaning of: relative transmission, penetration measurement, linear attenuation coefficient
4. State Lambert- Beer law
5. Outline the principles of attenuation of a homogenous and a heterogeneous beam of radiation.
6. Explain what is meant by data acquisition geometry and data processing.
7. Describe the relationship between CT numbers and the linear attenuation coefficient.
8. States several reasons why a high KVP beam is used in CT.
9. Describe the relationship between CT numbers and the grayscale of the CT image.
10. Define window width and window level.
11. Discuss the characteristic features of the CT image.
12. Explain the relationship between pixel size and the field of view and matrix size.
13. Draw and label the major equipment components of a CT scanner.
14. Trace the flow of data in a CT scanner.
15. Describe each of the following: raw data, convolved data, reconstructed data, image data.
16. List the advantages and limitations of CT.

Week 4- Chapter 4 -Data Acquisition Concepts

1. Identify the basic components of a typical data acquisition scheme used in CT scanning.
2. Explain each of the following: scanning, ray, view, projection profile, data sample.
3. Describe the essential characteristics of 5 generations of CT data acquisition geometries.
4. Compare and contrast 2 types of slip-ring systems for use in CT scanners
5. Describe the elements of an x-ray generator used in CT.
6. Outline the main features of x-ray tubes, filtration, and collimation in CT.
7. Describe recent design innovations in CT x-ray tubes.
8. Describe briefly what is meant by each of the following characteristics of CT detectors: efficiency, stability, response time, dynamic range.
9. Outline the principles of each of the following types of detectors: scintillation detectors, gas ionization detectors.
10. Outline the essential design innovations and CT detectors and detector electronics.
11. State the purpose of the DAS and explain how it works.
12. Outline briefly the essential elements of 3 methods of increasing the number of samples (Transition measurements) needed for image reconstruction in CT

Week 5- Chapter 5 – Image Reconstruction

1. Describe briefly what is meant by each of the following: algorithms, Fourier transform, convolution, interpolation.
2. Explain briefly what is meant by the term "Image reconstruction from projections."
3. Trace the history of reconstruction techniques.
4. State the basic mathematical problem in CT.
5. Identify 3 classes of reconstruction algorithms.
6. Describe the back projection reconstruction algorithm and state it's fundamental limitation
7. Explain how the filtered back-projection algorithm works
8. State the role of interpolation in image reconstruction in single and multi-slice CT
9. List for operations of a 3-D surface display technique

Week 6- Chapter 6 - Iterative Reconstruction

1. Outline the assumptions made to derive the filtered back-projection algorithm
2. List 4 strategies to reduce noise in CT imaging
3. State 3 categories of Iterative reconstruction (IR) algorithms available from CT manufacturers
4. Describe 3 steps in a typical IR process without modeling.
5. State the meaning of the term modeling and list three models used in IR algorithms.
6. Identify the points where these models are applied during the CT image reconstruction process.
7. State 3 goals of using IR algorithms in CT
8. Provide examples of various IR algorithms available from CT manufacturers
9. List the characteristics on which the performance evaluation of IR algorithms compared with the FPB algorithm is based.

Week 7- Chapter 7: Basic Instrumentation

1. Describe the fundamental differences between computer hardware and computer software.
2. Identify the different types of computers architectures and processing operations.
3. Describe the components of the 3 major subsystems of a CT scanner.
4. Describe the characteristics of the CT gantry and the patient couch.
5. Describe each of the following elements of ACT computer and image processing system: Processing architecture, hardware, software
6. State what is meant by the graphics processing unit and identify its role in CT imaging.
7. Outline the characteristic features of CT image display, recording, and storage.
8. Describe the major components of a picture archiving and communications system and how it interfaces with a CT scanner.
9. Outline the main features of a CT control console.
10. Describe several hardware and software options for CT scanners.
11. Identify various accessories for use in CT.
12. Describe what is meant by the modular system concept and operating modes of a scanner.
13. Describe a typical room layout for a CT scanner.
14. Identify the major technical specifications for a CT scanner.

Week 7- Chapter 8: Image Post-processing and Visualization Tools

1. List 2 major classes of image manipulation techniques and provide examples of each.
2. Explain the concept of windowing in CT
3. Define window width (WW) and window level (WL)

4. Evaluate the effect of WW & WL on image contrast and image brightness respectively.
5. Describe briefly specialized computer programs for image manipulation.
6. Explain briefly how CT is used in radiation treatment planning.
7. Identify basic and advanced visualization tools for use in CT.
8. Identify the hardware components of advanced visualization and analysis CT workstation.

Week 7- Chapter 9: Image Quality

1. Identify several types of phantoms for measuring image quality in CT.
2. Define each of the following: spatial resolution, low contrast resolution, temporal resolution, noise, CT number accuracy and linearity, uniformity.
3. Discuss the factors affecting spatial and contrast resolution in CT
4. Discuss the factors affecting noise in CT.
5. Define the term artifact.
6. Discuss the types, causes, and reduction of artifacts in CT.

Week 8- Chapter 10: Radiation Dose in Computed Tomography

1. State 2 reasons why the dose in CT is of importance to the CT technologist.
2. Explain what is meant by exposure, absorbed dose, and effective dose.
3. Explain what is meant by stochastic effects and deterministic effects of radiation exposure, and provide examples of each class of bioeffects
4. Describe the characteristics of the CT beam geometry that affect the dose distribution in a patient
5. State the function that describes an arbitrarily shaped dose intensity along the patient access.
6. State several methods for measuring the dose in CT.
7. State what is meant by the CTDI, MSAD, and DLP
8. Describe the characteristics of CT scanner dosimetry phantoms.
9. Describe briefly the basic steps of the CT dose measurement procedure.
10. Outline the factors affecting dose in CT and explain various dose reduction methods.
11. Describe the basic principles of automatic tube current modulation
12. State what is meant by iterative reconstruction algorithms
13. Explain the meaning of the term "dose optimization"
14. Explain CT dose index registry.
15. Explain the image wisely and image gently campaigns.

Week 9- Chapter 11: Multi-slice Computed Tomography

1. Discuss the controversy surrounding the use of the term spiral and helical in volume CT.
2. Outline the scanning sequence of conventional CT and list its principal limitations.
3. List the requirements for volume data acquisition
4. Outline the physical principles, data acquisition, and image reconstruction technique for single slice spiral/helical CT
5. Describe the major equipment components of a single slice spiral/helical CT scanner.
6. Define and briefly explain each of the following: pitch, volume coverage, collimation and table speed, scan time, reconstruction increment.
7. Describe the essential elements of image quality and radiation dose for single-slice spiral/helical CT.

8. State the advantages and limitations of single-slice spiral/helical CT
9. Briefly explain 3 major technical advances in volume CT scanning
10. Describe the essential characteristics of multi slice detectors.
11. State the limitations of single-slice volume CT scanning.
12. Trace the evolution of multi-slice volume CT scanners
13. Compare and contrast data and image reconstruction for single-slice and multi-slice volume CT, including cone-beam algorithms
14. Describe the essential features of each of the following equipment components: data acquisition components, multi slice detectors, slice thickness selection, data acquisition system, patient table, computer system.
15. Define and explain the goals of isotropic imaging
16. Describe the main technical aspects of the 320-slice dynamic volume CT scanner
17. Outline the major technical components of the dual-source CT scanner
18. State the advantages of multi-slice spiral/helical CT
19. List the clinical application of MSCT.
20. Identify potential applications of MSCT.

Week 10- Chapter 12- Other Applications of CT Imaging

1. Outline the basic technical aspects of cardiac CT imaging.
2. Describe the technical elements of CT angiography and outline its post processing techniques and visualization tools.
3. Discuss the technical factors involved in CT fluoroscopy.
4. Discuss the applications of CT and radiation therapy.
5. Define medical image fusion and list its application areas.
6. Describe the steps of MIF and list the clinical applications of MIF.
7. Define flat-detector CT and outline it's technical elements
8. Describe the technical components of breast CT.
9. Define CT screening and state the rationale for its use.
10. Explain briefly the nature of quantitative CT.
11. Describe the elements of multi-slice portable CT

Week 11- Chapter 13– 3-Dimensional Computed Tomography

1. Explain each of the following with respect to three dimensional concepts: for coordinates used in 3-D imaging, sequence in transforming 3-D space or scene space, modeling, shading, lighting, rendering
2. Explain what is meant by each of the following: slice imaging, projective imaging, volume imaging.
3. Identify four major components of a typical 3-D imaging system.
4. Describe briefly each of the 4 major steps in creating 3-D images.
5. Describe briefly each of the following 3-D rendering techniques: surface rendering, volume rendering, intensity projection renderings.
6. Compare each of the rendering techniques used in 3-D imaging.
7. Outline the characteristic features of standalone workstations for 3-D imaging.
8. Identify several clinical applications of 3-D imaging.
9. Identify the role of graphics processing unit in 3-D imaging.
10. State the meaning of virtual reality imaging (VRI)

11. Describe the 4 technical aspects of VRI.
12. Outline the clinical applications, advantages, and limitations of VRI.
13. Identify several software tools for VRI.
14. Explain briefly the features of flight path planning.
15. Identify the role of the technologist in 3-D imaging.

Week 12- Chapter 14- Positron Emission Tomography/CT (PET/CT) & Single Photon Emission Computed Tomography /CT (SPECT/CT)

1. Outline basic principles of radionuclide imaging, single-photon emission computed tomography and positron emission tomography
2. Defined the fundamentals of annihilation coincidence detection as it is applied to PET.
3. Describe the concepts behind time of flight (TOF) PET
4. Outline the basic steps of SPECT data acquisition.
5. Describe 3 components of a rotating gamma camera SPECT device.
6. List for differences between PET and SPECT
7. Discuss 2 approaches to attenuation correction for PET or SPECT
8. Discuss 3 ways that CT can be used in the context of hybrid imaging.
9. List 3 clinical applications where PET/CT has been shown to be of substantial value. Do the same for SPECT/CT

Week 13- Chapter 15- CT of the Head, Cerebral Vessels, Neck and Spine

1. Discuss the indications for CT of the head and face, cerebral blood vessels, neck, and spine.
2. Compare the role of CT with other imaging modalities.
3. Identify various anatomic structures for a CT of the head, neck, and spine.
4. Identify relevant patient preparation details that will minimize artifacts, ensure patient safety and comfort, and produce a study of optimal diagnostic quality when performing CT of the head, neck, and spine
5. Identify various positioning considerations when performing CT of the head, neck, and spine.
6. Describe briefly scanning protocols used for CT of the head, neck, spine, and cerebral blood vessels
7. Discuss the elements of radiographic techniques, including the influence of slice thickness, matrix size, and reconstruction algorithms used in CT of the head, neck, and spine.
8. Outline the use of contrast media in CT of the head, cerebral blood vessels, neck and spine.

Week 14- Chapter 14- CT of the Body

1. List the clinical indications for each of the following: mediastinum, lung, cardiac, spleen, bowel, pancreas, kidneys, adrenal glands, retroperitoneum, pelvis, trauma, vascular system.
2. Identify planning considerations for CT of the body procedures.
3. State the important information that should be provided by the technologist to a patient having CT scans of the body.
4. Discuss the use of both oral contrast media and intravenous contrast agents in body CT procedures.
5. Outline examples of CT scanning protocols for each of the following: thorax, abdomen, pelvis, musculoskeletal system

Week 14- Chapter 17 – Pediatric CT

1. State the basic tenets and other considerations necessary for an effective pediatric CT examination.
2. State the advantages of multi detector CT (MDCT) Compared to single-slice spiral CT (SSCT)
3. Identify new applications in pediatric CT imaging made possible with MDCT scanners.
4. Describe the major tasks of the CT technologist in performing a CT examination on a pediatric patient with respect to patient management, neonatal patients, sedation, immobilization, use of intravenous contrast media, radiation protection, scan planning and preparation, scan parameters
5. State the advantages of pediatric CT imaging of the brain, face, neck, and spine compared with magnetic resonance imaging (MRI)
6. Explain critical elements of positioning the pediatric patient for a CT examination.
7. Outline the necessary technical aspects of a pediatric CT examination.
8. Describe the importance of using protocols in pediatric CT
9. Outline each of the following elements of pediatric CT imaging of the chest and abdomen; musculoskeletal examinations; and CT angiography: indications, patient positioning, technical considerations, scanning protocols.

Week 15- Chapter 18 – Quality Control for CT

1. Explain what is meant by Quality Control (QC) for CT scanners.
2. State the benefits of a QC program for CT scanners.
3. Identify and describe the 3 essential steps in a QC program.
4. Identify the range of QC tests to be done by the technologist as prescribed by the ACR and the IAEA
5. Identify 3 categories of equipment and phantoms for CTQC tests.
6. Describe briefly the features of the ACR phantom
7. Outline the 3 basic tenets of a QC program for CT.
8. Describe briefly each of the following with respect to CT QC: Exposure technique selection, testing frequency, limits of a passing test.
9. Outlined the visual inspection requirements for CT QC
10. State the acceptance criteria for the following ACR CT accreditation QC tests using the ACR phantom: light accuracy alignment, high contrast resolution, low contrast resolution, image uniformity, noise, CT number accuracy, slice thickness.
11. Identify other CTQC test not listed in 10 above.

Students – please refer to the Instructor's Course Information sheet for specific information on assessments and due dates.

Part III: Grading and Assessment

EVALUATION OF REQUIRED COURSE MEASURES/ARTIFACTS*:

Students' performance will be assessed and the weight associated with the various measures/artifacts are listed below.

EVALUATION*

Tests	60%
Assignments	20%
Final Exam	20%
	100%

Students, for the specific number and type of evaluations, please refer to the Instructor's Course Information Sheet.

GRADING SYSTEM:

Please note the College adheres to a 10-point grading scale A = 100 – 90, B = 89- 80, C = 79 – 70, D = 69 – 60, F = 59 and below. You must have your dean's approval if changes in the scale are made.

The Medical Imaging Sciences adheres to the following:
Semester exams and Final Exam comprise your grade. Grades are assigned according to raw score divided by total possible points. Grading scale is as follows:
92-100-A
83-91- B
74-82- C
65-73-D
64 and below- F

Grades earned in courses impact academic progression and financial aid status. Before withdrawing from a course, be sure to talk with your instructor and financial aid counselor about the implications of that course of action. Ds, Fs, Ws, WFs and Is also negatively impact academic progression and financial aid status.

The Add/Drop Period is the first 5 days of the semester for **full term** classes. Add/Drop periods are shorter for accelerated format courses. Please refer to the academic calendar for deadlines for add/drop. You must attend at least one meeting of all of your classes during that period. If you do not, you will be dropped from the course(s) and your Financial Aid will be reduced accordingly.

Part IV: Attendance

Horry-Georgetown Technical College maintains a general attendance policy requiring students to be present for a minimum of 80 percent (80%) of their classes in order to receive credit for any course. Due to the varied nature of courses taught at the college, some faculty may require up to 90 percent (90%) attendance. Pursuant to 34 Code of Federal Regulations 228.22 - Return to Title IV Funds, once a student has missed over 20% of the course or has missed two (2) consecutive weeks, the faculty is obligated to withdraw the student and a student may not be permitted to reenroll. **Instructors define absentee limits for their class at the beginning of each term; please refer to the Instructor Course Information Sheet.**

For online and hybrid courses, check your Instructor's Course Information Sheet for any required on-site meeting times. Please note, instructors may require tests to be taken at approved testing sites, and if you use a testing center other than those provided by HGTC, the center may charge a fee for its services.

Part V: Student Resources

THE STUDENT SUCCESS AND TUTORING CENTER (SSTC):

The SSTC offers to all students the following **free** resources:

1. **Academic tutors** for most subject areas, **Writing Center support**, and **college success skills**.
2. Online **tutoring** and academic support resources.
3. Professional and interpersonal communication **coaching** in the EPIC Labs.

Visit the Student Success & Tutoring Center website for more information. To schedule tutoring appointments using TutorTrac, visit the Student Services tab in WaveNet. Email sstc@hgtc.edu or call SSTC Conway, 349-7872; SSTC Grand Strand, 477-2113; and SSTC Georgetown, 520-1455, or go to the Online Resource Center to access on-demand resources.

STUDENT INFORMATION CENTER: TECH Central

TECH Central offers to all students the following **free** resources:

1. **Getting around HGTC**: General information and guidance for enrollment!
2. Use the Online Resource Center (ORC) including scheduled technology training, Office 365 support, password resets, and username information.
3. **Drop-in technology support or scheduled training** in the Center or in class.
4. **In-person workshops, online tutorials and more services** are available.
5. **Chat with our staff on TECH Talk**, our live chat service. TECH Talk can be accessed on the student portal and on TECH Central's website, or by texting questions to (843) 375-8552.

Visit the Tech Central website for more information. Live Chat and Center locations are posted on the website. Or please call (843) 349 – TECH (8324).

HGTC LIBRARY:

Each campus location has a library where HGTC students, faculty, and staff may check out materials with their HGTC ID. All three HGTC campus libraries are equipped with computers to support academic research and related school work; printing is available as well. Visit the Library website for more information or call (843) 349-5268.

STUDENT TESTING:

Testing in an **online/hybrid** course and in **make-up exam** situations may be accomplished in a variety of ways:

- Test administered within D2L
- Test administered in writing on paper
- Test administered through Publisher Platforms (which may have a fee associated with the usage)

Furthermore, tests may have time limits and/or require a proctor.

Proctoring can be accomplished either face-to-face at an approved site or online through RPNow, our online proctoring service. To find out more about proctoring services, please visit the Online Testing section of the HGTC's Testing Center webpage.

The **Instructor Information Sheet** will have more details on test requirements for your course.

DISABILITY SERVICES:

HGTC is committed to providing an accessible environment for students with disabilities. Inquiries may be directed to HGTC's Accessibility and Disability Service webpage. The Accessibility and Disability staff will review documentation of the student's disability and, in a confidential setting with the student, develop an educational accommodation plan.

Note: It is the student's responsibility to self-identify as needing accommodations and to provide acceptable documentation. After a student has self-identified and submitted documentation of a disability, accommodations may be determined, accepted, and provided.

STATEMENT OF EQUAL OPPORTUNITY/NON-DISCRIMINATION STATEMENT:

Horry-Georgetown Technical College prohibits discrimination and harassment, including sexual harassment and abuse, on the basis of race, color, sex, national or ethnic origin, age, religion, disability, marital or family status, veteran status, political ideas, sexual orientation, gender identity, or pregnancy, childbirth, or related medical conditions, including, but not limited to, lactation in educational programs and/or activities.

TITLE IX REQUIREMENTS:

All students (as well as other persons) at Horry-Georgetown Technical College are protected by Title IX—regardless of their sex, sexual orientation, gender identity, part- or full-time status, disability, race, or national origin—in all aspects of educational programs and activities. Any student, or other member of the college community, who believes that he/she is or has been a victim of sexual harassment or sexual violence may file a report with the college's Chief Student Services Officer, campus law enforcement, or with the college's Title IX Coordinator or designee.

> *Faculty and Staff are required to report incidents to the Title IX Coordinators when involving students. The only HGTC employees exempt from mandatory reporting are licensed mental health professionals (only as part of their job description such as counseling services).

INQUIRIES REGARDING THE NON-DISCRIMINATION/TITLE IX POLICIES:

Student and prospective student inquiries concerning Section 504, Title II, Title VII, and Title IX and their application to the College or any student decision may be directed to the Vice President for Student Affairs.

Dr. Melissa Batten, VP Student Affairs
Title IX, Section 504, and Title II Coordinator
Building 1100, Room 107A, Conway Campus
PO Box 261966, Conway, SC 29528-6066
843-349-5228
Melissa.Batten@hgtc.edu

Employee and applicant inquiries concerning Section 504, Title II, and Title IX and their application to the College may be directed to the Vice President for Human Resources.

Jacquelyne Snyder, VP Human Resources
Affirmative Action/Equal Opportunity Officer and Title IX Coordinator
Building 200, Room 205B, Conway Campus
PO Box 261966, Conway, SC 29528-6066
843-349-5212
Jacquelyne.Snyder@hgtc.edu