COURSE SYLLABUS
TM 220 COMPUTED TOMOGRAPHY PHYSICS

CLASS HOURS: 4  CREDIT HOURS: 4
LABORATORY HOURS: 0

CATALOG COURSE DESCRIPTION: This course is one of a three course set in whole body Computed Tomography (CT) imaging. The complete set provides formal specialized training in CT whole body imaging prior to independent performance. Topics included in this course are history of computed tomography, fundamentals of computers, scanning methods, digital imaging, quality control, and radiation protection.

ENTRY LEVEL STANDARDS: Radiologic Technologist registered by the American Registry of Radiologic Technologists (ARRT)(R).

PREREQUISITES: Graduate of CAHEA/JRCERT accredited Radiologic Technology Program and certified or eligible for certification by the American Registry of Radiologic Technologists

COREQUISITES: TM 210, TM 230

TEXTBOOK(S) AND OTHER REFERENCE MATERIAL BASIC TO COURSE:


Required Student Learning Outcomes (Program Student Learning Outcomes and Course Student Learning Outcomes):
PSLO # 1: The computed tomography technical certificate program exists to prepare graduates who possess the knowledge, skill, and affect to meet the demands of an entry-level position in computed tomography. (COM, ANA, CT, TEC, CUL, KNO)

CSLO #1  Discuss the history of CT and its advantages as an imaging modality in the health field.
CSLO #2  Discuss the background of computer systems and how they have evolved in Radiology departments today.
CSLO #3  Trace the history of digital image processing, the steps in digitizing an image, the characteristics of digital image processing, and the advantages of digitizing an image.
CSLO #4  Demonstrate knowledge of the basic principles of Computed Tomography.
CSLO #5  Identify and describe the basic components of a data acquisition scheme in CT with consideration to generator type, detector characteristics, and the five generations of CT Scanners.
CSLO #6  Differentiate dynamic versus spiral and helical scanning.
CSLO #7  Trace the history of image reconstruction techniques while identifying the various algorithms used during this process.
CSLO #8  Describe the major components of the CT Scanner, implementing the elements of a CT image processing system, CT gantry, display, storage and recording devices.
CSLO #9  Evaluate the techniques used for image manipulation in CT.
CSLO #10  Identify the properties which effect image quality in CT Scanning.
CSLO #11  Discuss biological effects of CT and adhere to radiation protection guidelines.
CSLO #12  Explain quality control for CT Scanners, stating the benefits of a QC program selection of technique for QC measurements and tests performed in a QC program.
CSLO #13  Survey post processing computer manipulations, e.g. 3-D CT reconstruction.
Other Learning Indicators or Objectives (optional): The student will:

Part I  An Overview of Computed Tomography (A)
1. State the meaning of the following terms:
   - tomography
   - transverse axial tomography
   - image reconstruction
   - emission CT
   - transmission CT
2. List other terms synonymous with CT.
3. List three steps that constitute the CT process and briefly describe each.
4. Identify the major components of a CT scanner.
5. Describe briefly how a CT scanner works.
6. Describe the early CT experiments performed by G. N. Hounsfield.
7. State the contribution of A.M. Cormack to the development of CT.
8. Identify several CT developments for the period between 1973 and 1983.
9. State other uses of CT apart from those in clinical medicine.
10. Define digital image processing.
11. Identify the essential components of a digital imaging system.
12. State the meaning of each of the following: ADC, DAC, PACs.
13. State what is meant by a 3-D rendering technique.
14. List and briefly explain the three steps of surface and volume based 3-D rendering techniques.

Part II  Understand Computer Systems (B)
1. Describe a computer system in terms of its three essential elements - hardware, software and people.
2. Identify significant developments in the history of computers.
3. Describe the major features of four classes of computers.
4. Describe the physical organization of a microcomputer system.
5. Explain briefly what is meant by each of the following: distributed processing, multitasking, multiprocessing, parallel processing, and pipeline processing.
6. Convert decimal to binary numbers, and binary to decimal numbers.
7. Briefly explain the purpose of each of the following in an analog-to-digital converters: sampler, quantizer, and coder.
8. Describe each of the following hardware components of a computer: input hardware, processing hardware, output hardware.
9. Explain how data is stored on secondary storage devices such as magnetic tape, disks, and optical disks.
10. Define the storage capacity of a computer.
11. Discuss computer software in terms of: system software applications software.
12. List several types of computer languages.
13. Describe a typical scheme for communicating data using computers.
14. Identify four types of computers network topologies.
15. State the meaning of each of the following: LAN, MAN, WAN, AI, Viruses.
16. State the imaging an non-imaging applications of computers.

Part III  Explain Digital Image Processing (C)
1. Trace the history of digital image processing.
2. Describe briefly how images are formed and how they can be represented.
3. Define each of the following terms: Objects, images, analog images, digital images, processing, digital image processing.
4. Describe each of the following steps in digitizing an image: scanning, sampling, quantization.
5. State the purpose of the analog-to digital converter and describe the following two characteristics: speed and accuracy.
6. List the advantage of digitizing images.
7. List four image processing techniques and explain how the point processing technique works.
8. State the meaning of each of the following:
   - gray level mapping
   - look-up table
   - histogram
   - spatial frequency filtering
9. List two ways to perform spatial frequency filtering and explain briefly how convolution works.
10. State the purpose of each of the following hardware components of a digital image processing system:
    - analog-to-digital converter
    - image storage
    - internal image processor
    - host computer
11. Explain how similar steps in digitizing an image are applied to CT imaging.

Part IV Principles of Computed Tomography (D)
1. State the limitations of radiography and conventional tomography.
2. Explain briefly how these limitations are overcome by CT.
3. Explain the meaning of the term data acquisitions and describe two methods of acquiring data from the patients.
4. Define each of the following:
   - relative transmission
   - penetration measurement
   - linear attenuation coefficient
5. State Lambert-Beer’s law.
6. Compare and contrast the attenuation of a homogenous and a heterogenous beam of radiation.
7. Explain what is meant by the terms data acquisition geometry and data processing.
8. Describe the relationship between CT numbers and the linear attenuation coefficient.
9. State several reasons why a high kVp is generally used in CT.
10. Describe the relationship between CT numbers and the gray scale of the CT image.
11. Define each of the following:
    - Window Width (WW)
    - Window Level (WL)
12. Describe the format of the CT image.
13. Explain what is meant by the field of view (FOV) and show how it is related to pixel size and matrix size.
14. Identify the equipment components that make up a CT scanner.
15. Describe the flow of data in a CT scanner.
16. Define each of the following:
    - raw data
    - convolved data
    - reconstructed data or image data
17. List the advantages and limitations of CT.

Part V Data Acquisitions of CT (E)
1. Identify and describe the basic components of a data acquisitions scheme in CT.
2. Explain the meaning of each of the following terms:
   - scanning
   - ray
   - view
   - projection profile
   - data sample
3. Identify by category five generations of CT scanners and state the basis for the categorization.
4. Describe the characteristics of five generations of CT scanner geometries.
5. Define the term slip-ring and describe the essential elements of two types of slip-rings: low-voltage and high voltage.
6. Describe the type of generators used in CT scanners.
7. Describe the main features of x-ray tubes for CT scanners.
8. Discuss filtration and collimation in CT.
9. Explain each of the following CT detector characteristics:
   - efficiency
   - stability
   - response time
   - dynamic range
10. Describe the characteristic of each of the following detectors:
    - scintillation detectors
    - gas-ionization detectors
11. State the purpose of the data acquisition system (DAS) and describe how it works.
12. Identify and briefly explain three methods used to increase the number of measurements or samples needed for image reconstruction.

Part VI Spiral/Helical CT (F)
1. Describe the scanning sequence of conventional slice-by-slice CT scanning.
2. List the limitations of slice-by-slice CT scanning.
3. Define the following terms:
   - spiral CT
   - helical CT
   - volume data acquisition
4. State the requirements for volume data acquisition.
5. Describe the principles of spiral/helical CT with respect to:
   - data acquisition
   - image reconstruction
6. Define the following terms:
   - pitch
   - pitch factor
   - image index
7. Explain briefly what is meant by the term double-helix, double-volume scanning.
8. List the advantages of spiral/helical CT.

Part VII Image Reconstruction (G)
1. Trace the sequence of events after the signals leave the CT detectors.
2. Define each of the following:
   - algorithm
   - Fourier transform
   - convolution
   - interpolation
3. Explain briefly what is meant by "image reconstruction from projections."
4. Trace the history of reconstruction techniques.
5. State the basic mathematical problem in CT.
6. Identify three classes of image reconstruction algorithms
7. Describe how back-projection is accomplished and state the basic limitation of this algorithm.
8. List two types of analytic reconstruction algorithms.
9. Explain how filtered back-projection works.
10. List four operations of a 3-D surface display technique.

Part VIII Components of a CT Scanner (H)
1. Identify the three major systems of a CT scanner and list the components of each.
2. Describe the components of the CT gantry (including the x-ray tube and generator, as well as the data acquisitions system), and the basic features of the patient table.
3. Describe the following three elements of a CT computer and image processing system:
   - processing architecture
   - hardware
   - software
4. Describe the characteristics of image display, storage, and recording in CT.
5. Describe the main components of a CT control console.
6. Describe several hardware and software options for CT.
7. Identify accessories for use in CT.
8. Describe briefly what is meant by each of the following:
   - modular design concept
   - operating modes of the scanner
9. Describe a typical room layout for a CT scanner.
10. Identify the major technical specifications and features of a CT scanner.

Part IX Image Manipulation (I)
1. Define the term image manipulation.
2. List two major classes of image manipulation techniques and give examples of each.
3. Explain what is meant by windowing in CT.
4. Define window width and window level
5. Discuss the manipulation of WW and WL.
6. Evaluate the effect of WW on image contrast.
7. Evaluate the effect of WL on image display.
8. Briefly describe each of the following:
   - multiplanar reconstruction
   - quantitative CT
   - xenon CT
   - 3-D imaging
9. Explain how CT is used in radiation therapy treatment planning.
10. List other computer programs for image processing in CT.

Part X. Image Quality (J)
1. Write out a general expression for image quality.
2. State several methods for measuring image quality.
3. Identify two popular types of phantoms for measuring image quality.
4. Define each of the following:
   - spatial resolution
   - contrast resolution
   - noise
   - linearity
   - cross-field uniformity
5. Discuss the factors affecting spatial resolution in CT.
6. Explain what is meant by high-resolution CT.
7. Discuss the factors affecting contrast resolution in CT.
8. Explain what is meant by a contrast-detail diagram.
9. Calculate the noise level in a CT image.
10. List seven sources of noise in CT.
11. Identify the sources of artifacts in CT.
12. Explain the production of the following artifacts in CT:
   - motion artifacts
   - metal artifacts
   - beam hardening artifacts
- partial volume artifacts
- ring artifacts

13. Explain how the above artifacts can be reduced.

Part XI  Measuring Patient Dose (K)
1. Describe the characteristics of the beam geometry for CT Scanning.
2. Trace the history of dose measurement in CT.
3. Describe briefly how an ionization chamber works.
4. Define each of the following:
   - multiple-scan average dose (MSAD)
   - computed tomography dose index (CTDI)
5. Describe briefly how the CTDI is measured.
6. Explain briefly the factors affecting dose in CT.
7. State the methods to reduce dose in CT.
8. Compare the dose from radiographic examinations with that of CT.

Part XII Quality Control for CT Scanners (L)
1. Explain what is meant by quality control for CT scanners.
2. State the benefits of a QC program.
3. Discuss the three basic tenets of a QC program for CT scanners.
4. Discuss the selection of a technique for QC measurements.
5. Explain what is meant by acceptable limits.
6. Describe each of the following QC tests with respect to equipment (or phantom), measurement procedure, expected results, acceptance limits and possible causes of failure:
   - average CT number for water
   - standard deviation of CT number in water
   - high contrast resolution
   - low contrast resolution
   - slice width
   - CT number versus algorithm
   - CT number versus slice width

Part XIV  Three-Dimensional Computed Tomography (N)
1. Explain briefly what is meant by post-processing of CT scan data.
2. Define the term multiplanar reconstruction (MPR).
3. Identify the major equipment that can be used to produce 3-D images.
4. Describe briefly the characteristics of a 3-D imaging workstation.
5. List the major drawbacks of 3-D CT reconstructions.
6. List the difficulties with CT scanning for 3-D reconstruction.

Required Assessments:
Assessment Names and Descriptions:
Each student will be required to be present in class, complete reading assignments, study guide activities, and written examinations. Mastery level for each unit examination must be 75% or greater.
### CSLO/Assessment Alignment:

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### Grading Scale or Policy, Weekly Outline, Topics, or Instructional Activities:

1. 60% average of unit tests
2. 20% average of study guide activities, other homework assignments
3. 20% Final examination