COURSE SYLLABUS
MRI 200 – Magnetic Resonance Imaging

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

CATALOG COURSE DESCRIPTION:
This is a one-semester weekend course designed to prepare the imaging Technologist for a professional career in Magnetic Resonance Imaging. Emphasis is placed on the foundations, concepts and procedures of MR Imaging.

ENTRY LEVEL STANDARDS:
Graduate from a CAHEA / JRCERT approved program in Radiologic Technology. High self-motivated individual with a desire to become a skilled member of the Magnetic Resonance Imaging technology profession.

PREREQUISITE:
Registered Technologist by the American Registry of Radiologic Technologists. Registry/Certification eligible students must be approved by the MRI Education Advisory Committee. All others may audit with approval.

TEXTBOOKS(S) AND OTHER REFERENCE MATERIAL BASIC TO COURSE:
Sectional Anatomy for Imaging Professionals by Kelly

MRI for Technologists by Woodward

MRI in Practice by Westbrook & Kaut-Watson

Required Student Learning Outcomes (Program Student Learning Outcomes and Course Student Learning Outcomes):

PSLO #1  The magnetic resonance imaging technical certificate exists to prepare graduates who possess the knowledge, skill, and affect to meet the demands of an entry-level position in magnetic resonance imaging. (COM, ANA, CT, TECH, CUL, KNO)

CSLO #1  Discuss the history of MRI and its advantages as an imaging modality in the health field.
CSLO #2  Briefly summarize the basic principles of Magnetic Resonance.
CSLO #3  Relate quantum and classical mechanics, net magnetization, and reference frames to Nuclear Magnetism.
CSLO #4  Describe how RF pulses and pulse sequences generate the NMR signals used to make an image.
CSLO #5  Understand the role of spectroscopy and its aid in diagnosis.
CSLO #6  Understand the three principal NMR parameters: spin density, T1 relaxation time, and T2 relaxation time; what they represent and how they are measured.
CSLO #7  Describe the three main components of the MR imager (gantry, operating console, and computer) and their subsystems.
CSLO #8  Understand the sequence of events surrounding the acquisition of a Magnetic Resonance Image.
CSLO #9  Understand the necessity of digital imaging and the characteristics of the digital computer, particularly the formation of MR images.
CSLO #10  Explain how pulse sequences are the instructions to the magnet on how to make an image.
CSLO #11 Explain how MR images are in the category of visual, representational digital images; what they represent and how they are formed.

CSLO #12 Discuss the strategies and pulsing techniques involved in decreasing imaging times by applying fast imaging techniques.

CSLO #13 Identify the three types of artifacts found in MRI and tell whether they are patient- or system-related.

CSLO #14 Discuss the possible biologic effects of MR in regards to magnetic fields and RF exposure, and adhere to the recommended guidelines.

CSLO #15 Identify coronal, sagittal, and transverse anatomy in each of the following sections: head, neck, spine, thorax, abdomen, pelvis, and extremities.

CSLO #16 Recognize disease processes in the body and how they affect the MR image.

CSLO #17 Evaluate the diagnostic quality of MR images and identify the methods of correction, if necessary.

Other Learning Indicators or Objectives (optional): An Overview of Magnetic Resonance:
1. Discuss the historical findings of Block, Damadian and Lauterbur.
2. Explain why contrast resolution is the principal advantage of MRI.
3. List the anatomic planes now images with MRI.
4. Explain why spectroscopy is another advantage to MRI.
5. Explain what type of radiation is used in MR imaging.
6. List the three main components of a MR imager.
7. Explain how net magnetization is created when a patient is placed in a strong magnetic field.
8. Explain the wobble of a hydrogen nucleus in the presence of a magnetic field.
9. Explain the gyromagnetic ratio of hydrogen.
10. Identify the two factors which determine precessional frequency.
11. Explain resonance in relation to the precessing hydrogen nuclei.
12. Explain what happens when RF is pulsed into the body.
13. Explain the free induction decay signal.
14. Explain the result of Fourier transformation.
15. Explain what happens when a gradient magnetic field is applied.
16. Define:
   radio-frequency (RF)
   contrast resolution
   spatial resolution
   gantry
   vector
   Bo
tesia (T)
net magnetization
precession
Larmor equation
Larmor frequency
resonance
equilibrium
free induction decay (FID)
relaxation time
Fourier transformation (FT)
gradiant magnetic field

Nuclear Magnetism:
1. Identify the spin quantum number of H.
2. Explain the result of a spin being quantized.
3. Explain the make up of the nuclear magnetic moment intensity.
4. Describe nuclear magnetic moment from the classical mechanical point of view and how it interacts with an externally applied magnetic field.
5. Describe net magnetization.
6. Describe the coordinate system used to construct vector diagrams.
7. Explain the equilibrium value of the net magnetization vector.
8. Explain how the intensity of the NMR signal is directly dependent on the value of M.
9. Explain what would be necessary to observe net magnetization, Mz.
10. Describe what actually determines the Z axis direction.
11. Discuss how the net magnetization is tipped off the Z axis.
12. Describe the motion of the net magnetization within the rotating frame of reference.
13. Define:
   - quantum mechanism
   - classical mechanics
   - spin quantum number
   - nuclear magnetic moments
   - Bo
   - net magnetization
   - Mo
   - Mz
   - Mx
   - My
   - rotating frame
   - B1

NMR Signals:
1. Explain what causes the net magnetization to be at equilibrium.
2. Discuss what physical factors determine the magnitude of the net magnetization at equilibrium.
3. Explain what is necessary to receive a signal from the patient.
4. Explain what two factors determine the final tip angle.
5. Describe the difference between hard and soft pulses.
6. Explain how hard and soft pulses are most commonly labeled.
7. Explain XY magnetization.
8. Explain why Mxy precession occurs.
9. Explain why the XY and the Z components are independent of each other.
10. Explain how an oscillating NMR signal is received.
11. Describe a simple RF pulse diagram.
12. Explain what is needed to produce a spin echo pulse sequence.
13. Explain what is unique about the inversion recovery pulse sequence.
14. Explain why repetition time is important.
15. Define:
   - equilibrium
   - Mxy
   - tip angle
   - pulse
   - partially saturated
   - saturated
   - pulse sequence
   - TE
   - Ti
   - TR
MRI Parameters:
1. Explain why spin density is proportional to signal intensity.
2. Describe T1 relaxation time. Explain also why it is called the longitudinal or spin-lattice relaxation time.
3. Describe T2 relaxation time. Explain also why it is called the transverse or spin–spin relaxation time.
4. Explain the phenomenon of phase coherence.
5. Explain the T2 relaxation which results from inhomogeneities in the magnetic field.
6. Briefly explain how to measure T2.
7. Briefly explain how to measure T1.
8. Compare T1 versus T2 measurements.
9. Define:
   - spin density
   - T1 relaxation time
   - lattice T2 relaxation
   - phase coherence
   - T2 relaxation
   - dephase

MRI Hardware:
1. Describe the design of permanent magnets.
2. Describe the advantages and disadvantages of using resistance electromagnets.
3. Describe a superconducting magnet and discuss the advantages and disadvantages of its use.
4. Explain how the superconducting imager is kept cold.
5. Explain what is meant by shimming the magnet.
6. Explain the functions of the X, Y, and Z gradients, both independently and combined.
7. Describe the RF probe.
8. Briefly describe the unique design of surface coils and their function.
9. Discuss the similarities and differences of MRI and CT operating consoles.
10. Discuss the important aspects of the MRI computer in terms of storage capacity, computer speed, and operating system.
11. Define:
    - gantry
    - electromagnets
    - cryogenic gases
    - dewars
    - gradient magnetic fields
    - gradient coils
    - shim coils
    - frequency synthesizer
    - saddle coil
    - surface coil
    - multitasking
    - multiuser

The Purchase Decision and Site Selection:
1. Discuss what must first be decided before deciding what type of imager to purchase.
2. Compare the advantages and disadvantages of the various MRI systems.
3. Discuss the four options for locating a MR imager.
4. Discuss the effects of the magnet on the environment.
5. List various types of equipment that cannot be functional in the fringe magnetic field.
6. Discuss the possible effects of the environment on the MR imager.
7. List various types of ferromagnetic objects that should remain outside of the fringe magnetic fields.
8. Discuss the shielding of the MR imager from outside electromagnetic radiation.
9. Discuss the support areas necessary in the general design of the MR facility.
10. Discuss the special construction materials and techniques needed in the design of the MR facility.
11. Define:
   fringe magnetic field
   Faraday cage

Digital Imaging:
1. Describe the binary number system.
2. Convert decimal values to binary values – 204, 80, 150, 128.
3. Convert binary values to decimal values – 1101 1011, 1111 1010, 0111 0010, 0011 1111.
4. Express binary numbering system into computer terminology.
5. Describe the precision of a computer system.
6. Explain the dynamic range of an imaging system.
7. Express the process of sampling as used in the NMR system.
8. Explain the difference between high spatial frequency and low spatial frequency.
9. Explain the relationship between spatial resolution and image matrix.
10. Explain how spatial frequencies of an image are plotted.
11. Explain how a magnetic field gradient must be used to achieve spatial localization.
12. Explain projection reconstruction, and why it is not the method of choice for MR imaging.
13. Explain the sequence of events in the 2DFT imaging technique.
14. Describe the two most common artifacts of 2DFT imaging.
15. Define:
   digital imaging
   spatial location
   bit
   encode
   bytes
   word
   precision
   dynamic range
   false contouring
   aliased
   image matrix
   pixels
   voxels
   undersampling

The Musical Score (Pulse Sequences):
1. Explain the purpose of a pulse sequence.
2. Discuss the key features of the magnet that distinguishes a MR imager from a NMR spectrometer.
3. Explain how any given slice in the body, in any plane, can be selectively excited.
4. Discuss what determines the thickness of the slice selected.
5. In regards to frequency encoding, phase encoding, and spatial frequency, discuss how a pixel is localized within an image.
6. Discuss the sequence of events necessary for a partial saturation pulse sequence.
7. Discuss the sequence of events necessary for an inversion recovery pulse sequence.
8. Discuss the sequence of events necessary for the spin echo pulse sequence.
9. Describe multislice, multiecho spin echo imaging.
10. Define:
    TR interval
    signal averaging
    multislice imaging
    TI interval
    TE
Magnetic Resonance Images:
1. Explain how any image is made visual.
2. Discuss the color receptors of the human eye. Include the different color combinations and shades of gray facts about the eye.
3. Explain the importance of a large image memory bank.
4. Explain why medical images are representational.
5. Briefly describe how a radiograph is essentially an electron density map of the body.
6. Explain how MR images are really three-dimensional images.
7. Identify the basic geometric factors relevant in the evaluation of the spatial aspects of an image.
8. Explain how pixel character normalcy is determined.
9. Discuss the significance of pixel brightness in MR images.
10. Identify the MRI parameters responsible for pixel character.
11. Explain what is meant by pure MR images.
12. Discuss what is meant by partial saturation.
13. Explain the reasoning behind inversion recovery pulse sequences.
14. Explain how spin echo images are weighted, and which images are best for anatomy and pathology.
15. Define:
   - pattern recognition
   - ROI
   - weighted images
   - saturated
   - refocusing pulse

Fast Imaging Techniques:
1. Explain two methods of sampling only part of the data set in order to reduce scan time.
2. Explain how the use of very short repetition times, low tip angles, and gradient magnetic field refocusing can be used to produce diagnostic images in a very short amount of time.
3. Understand that different MR imager manufacturers have different ways of naming their fast imaging techniques.

MRI Artifacts:
1. Explain how ferromagnetic materials can produce local signal loss and warping distortions of the image.
2. Identify the different types of patient-related magnetic and RF field distortion artifacts.
3. Identify the different types of system-related magnetic RF field distortion artifacts.
4. Discuss the aliasing artifact in image reconstruction, how and when it occurs.
5. Describe the following artifacts in image reconstruction: partial volume averaging, truncation, and the zipper artifact.
6. Discuss the different types of system-related and patient-related noise-induced artifacts.

Biologic Effects of MRI:
1. Discuss the investigations and findings on the effects of static and transient magnetic fields.
2. Discuss the effects of exposure to RF fields.
3. Discuss the effects of transient magnetic fields in terms of human responses.
4. Discuss the effects of RF exposure in terms of human response.
5. Discuss the recommended guidelines for maximum permissible operating intensities.
6. Define: SAR
III.B MANY ANATOMIC STRUCTURES PREVIOUSLY INVISIBLE TO OTHER IMAGING MODALITIES ARE MORE EASILY DEFINED BY MRI. This is accomplished not only by using different imaging planes but also by using various pulse sequences and imaging parameters to accentuate specific areas or structures in question. In each of the following anatomy sections, specific identifiable structures are listed for each imaging plane. The student will be able to:

1) Identify on the MR image each of the structures specified for each imaging plane
2) Discuss the different pulse sequence designs used to illustrate the variable anatomic and physiologic information that can be displayed in each section.

HEAD AND NECK IMAGING

I. Transaxial plane:
- gray matter
- white matter
- inner table calvarium
- diploe
- lateral ventricle
- subcutaneous fat (scalp)
- falx/interhemispheric fissure
- corpus callosum (genu)
- splenium of corpus callosum
- inferior sagittal sinus
- superior sagittal sinus
- frontal sinus
- third ventricle
- thalamus
- orbital globe
- retrobulbar space (fat)
- lens
- lateral mass of atlas
- ramus of mandible
- sublingual gland

<table>
<thead>
<tr>
<th>Structures</th>
<th>Identifiable Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>gray matter</td>
<td>spinal cord</td>
</tr>
<tr>
<td>white matter</td>
<td>medical rectus</td>
</tr>
<tr>
<td>inner table calvarium</td>
<td>lateral rectus</td>
</tr>
<tr>
<td>diploe</td>
<td>optic nerve</td>
</tr>
<tr>
<td>lateral ventricle</td>
<td>anterior cerebral artery</td>
</tr>
<tr>
<td>subcutaneous fat (scalp)</td>
<td>middle cerebral artery</td>
</tr>
<tr>
<td>falx/interhemispheric fissure</td>
<td>posterior cerebral artery</td>
</tr>
<tr>
<td>corpus callosum (genu)</td>
<td>midbrain</td>
</tr>
<tr>
<td>splenium of corpus callosum</td>
<td>occipital lobe</td>
</tr>
<tr>
<td>inferior sagittal sinus</td>
<td>pituitary gland</td>
</tr>
<tr>
<td>superior sagittal sinus</td>
<td>odontoil process</td>
</tr>
<tr>
<td>frontal sinus</td>
<td>cerebellar hemisphere</td>
</tr>
<tr>
<td>third ventricle</td>
<td>sphenoid sinus</td>
</tr>
<tr>
<td>thalamus</td>
<td>internal carotid artery</td>
</tr>
<tr>
<td>orbital globe</td>
<td>pons</td>
</tr>
<tr>
<td>retrobulbar space (fat)</td>
<td>petrous bone</td>
</tr>
<tr>
<td>lens</td>
<td>mastoid air cells</td>
</tr>
<tr>
<td>lateral mass of atlas</td>
<td>fourth ventricle</td>
</tr>
<tr>
<td>ramus of mandible</td>
<td>CSF in sulci</td>
</tr>
<tr>
<td>sublingual gland</td>
<td>frontal lobe</td>
</tr>
</tbody>
</table>

II. Coronal plane:
- nasopharynx
- epiglottis
- external auditory canal
- maxillary sinus
- facial fat
- inferior nasal turbinate (concha)
- orbital globe
- frontal sinus
- longitudinal fissure
- frontal lobe
- orbital fat
- nasal cavity
- frontal bone
- orbital roof
- medial rectus muscle
- inferior rectus muscle
- lateral rectus muscle

<table>
<thead>
<tr>
<th>Structures</th>
<th>Identifiable Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>nasopharynx</td>
<td>superior rectus muscle</td>
</tr>
<tr>
<td>epiglottis</td>
<td>ethmoid sinus</td>
</tr>
<tr>
<td>external auditory canal</td>
<td>middle nasal turbinate</td>
</tr>
<tr>
<td>maxillary sinus</td>
<td>tongue</td>
</tr>
<tr>
<td>facial fat</td>
<td>temporal lobe</td>
</tr>
<tr>
<td>inferior nasal turbinate (concha)</td>
<td>sphenoid sinus</td>
</tr>
<tr>
<td>orbital globe</td>
<td>corpus callosum</td>
</tr>
<tr>
<td>frontal sinus</td>
<td>optic canal</td>
</tr>
<tr>
<td>longitudinal fissure</td>
<td>soft palate</td>
</tr>
<tr>
<td>frontal lobe</td>
<td>mandible</td>
</tr>
<tr>
<td>orbital fat</td>
<td>lateral ventricle</td>
</tr>
<tr>
<td>nasal cavity</td>
<td>optic chiasm</td>
</tr>
<tr>
<td>frontal bone</td>
<td>pituitary infundibulum</td>
</tr>
<tr>
<td>orbital roof</td>
<td>pituitary gland</td>
</tr>
<tr>
<td>medial rectus muscle</td>
<td>oropharynx</td>
</tr>
<tr>
<td>inferior rectus muscle</td>
<td>third ventricle</td>
</tr>
<tr>
<td>lateral rectus muscle</td>
<td>falx cerebi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structures</th>
<th>Identifiable Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>superior rectus muscle</td>
<td>caudate nucleus</td>
</tr>
<tr>
<td>ethmoid sinus</td>
<td>clivus</td>
</tr>
<tr>
<td>middle nasal turbinate</td>
<td>atlantoaxial joint</td>
</tr>
<tr>
<td>tongue</td>
<td>pons</td>
</tr>
<tr>
<td>temporal lobe</td>
<td>cervical vertebra</td>
</tr>
<tr>
<td>sphenoid sinus</td>
<td>parotid gland</td>
</tr>
<tr>
<td>corpus callosum</td>
<td>external auditory canal</td>
</tr>
<tr>
<td>optic canal</td>
<td>mandibular condyle</td>
</tr>
<tr>
<td>soft palate</td>
<td>cerebral aqueduct of Sylvius</td>
</tr>
<tr>
<td>mandible</td>
<td>cerebellum</td>
</tr>
<tr>
<td>lateral ventricle</td>
<td>spinal cord</td>
</tr>
<tr>
<td>optic chiasm</td>
<td>parietal lobe</td>
</tr>
<tr>
<td>pituitary infundibulum</td>
<td>fourth ventricle</td>
</tr>
<tr>
<td>pituitary gland</td>
<td>occipital lobe</td>
</tr>
<tr>
<td>oropharynx</td>
<td>Foramen Magendie</td>
</tr>
<tr>
<td>third ventricle</td>
<td>transverse sinus</td>
</tr>
<tr>
<td>falx cerebi</td>
<td>straight sinus</td>
</tr>
</tbody>
</table>
### III. Sagittal plane:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Structures</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>superior sagittal sinus</td>
<td>maxillary sinus</td>
<td>bone marrow</td>
</tr>
<tr>
<td>parietal lobe</td>
<td>cerebellar hemisphere</td>
<td>scalp</td>
</tr>
<tr>
<td>frontal lobe</td>
<td>occipital condyle</td>
<td>pituitary gland</td>
</tr>
<tr>
<td>corpus callosum body</td>
<td>superior rectus muscle</td>
<td>soft palate</td>
</tr>
<tr>
<td>lateral ventricle</td>
<td>genu corpus callosum</td>
<td>occipital lobe</td>
</tr>
<tr>
<td>splenium corpus callosum</td>
<td>thalamus</td>
<td>Aqueduct of Sylvius</td>
</tr>
<tr>
<td>fourth ventricle</td>
<td>midbrain</td>
<td>occipital bone</td>
</tr>
<tr>
<td>medulla oblongata</td>
<td>opti chiasm</td>
<td>adenoids</td>
</tr>
<tr>
<td>anterior and posterior arch of C1</td>
<td>infundibulum</td>
<td>optic nerve</td>
</tr>
<tr>
<td>nasopharynx</td>
<td>pituitary fossa</td>
<td>inferior rectus muscle</td>
</tr>
<tr>
<td>tongue</td>
<td>pons</td>
<td>temporal bone</td>
</tr>
<tr>
<td>ethmoid sinus</td>
<td>sphenoid sinus</td>
<td>temporomandibular joint</td>
</tr>
<tr>
<td>orbital fat</td>
<td>clivus</td>
<td>mandibular condyle</td>
</tr>
</tbody>
</table>

### SPINE IMAGING

The student will be able to:

1. Identify on the MR image each of the structures specified for each imaging plane.
2. Discuss the different pulse sequence designs used to illustrate the variable anatomic and physiologic information that can be displayed in each section.

#### Cervical Spine

I. **Transaxial plane:**
- vertebral artery
- subarachnoid space
- facet
- lamina
- anterior nerve root (ventral)
- posterior nerve root (dorsal)
- cervical vertebral body
- epidural fat
- spinous process
- cervical spinal cord white matter
- cervical spinal cord gray matter

II. **Coronal plane:**
- vertebral body
- intervertebral disc

III. **Sagittal plane:**
- odontoid
- cervical vertebral body
- cervical disc interspace
- cervical subarachnoid space
- spinous process
- lateral mass of C1
- cervical spine cord
- anterior and posterior
- arch of C1
- facet joint
- superior & inferior facet
- CSF in thecal sac
- epidural fat

#### Thoracic Spine

I. **Transaxial plane:**
- vertebral body
- spinal canal
- spinous process

II. **Coronal plane:**
- vertebral body
- intervertebral disc

III. **Sagittal plane:**
- thoracic spinous process
- intervertebral disc
- thoracic vertebral body
- thoracic spinal cord
- epidural fat
- CSF
- subarachnoid space
**Lumbosacral Spine**

I. **Transaxial plane:**
- psoas muscle
- paraspinal muscle
- dural sac
- nerve roots
- vertebral body
- pedicle
- lamina
- spinous process
- aorta
- facet joint
- epidural fat
- superior facet
- inferior facet
- disc interspace
- sacroiliac joint
- iliac bone
- transverse process of sacrum

II. **Coronal plane:**
- vertebral body
- intervertebral disc

III. **Sagittal plane:**
- vertebral body
- disc interspace
- lumbosacral interspace
- epidural fat
- conus medullaris
- dural sac
- spinous process
- superior facet
- inferior facet
- nerve root
- facet joint

**THORAX IMAGING**

The student will be able to:
1) Identify on the MR image each of the structures specified for each imaging plane.
2) Discuss the different pulse sequence designs used to illustrate the variable anatomic and physiologic information that can be displayed in each section

I. **Transaxial plane:**
- clavicle
- scapula
- humerus
- lung
- trachea
- esophagus
- ascending aorta
- descending aorta
- sternum
- spinal canal
- bronchi
- right ventricle
- left ventricle
- right atrium
- left atrium
- inferior vena cava
- interventricular septum
- mitral valve
- tricuspid valve

II. **Coronal plane:**
- clavicle
- ascending aorta
- descending aorta
- aortic arch
- main pulmonary artery
- right ventricle
- left ventricle
- interventricular septum
- humerus
- spinal canal
- trachea
- right atrium
- left atrium
- right main bronchus
- azygos vein
- liver
- spleen
- right lung
- left lung

III. **Sagittal plane:**
- lung
- liver
- trachea
- ascending aorta
- descending aorta
- aortic arch
- left atrium
- inferior vena cava
- right ventricle
- right atrium
- mediastinal fat
- sternum
- spine
- right atrium
ABDOMEN IMAGING

The Student will be able to:
1) Identify on the MR image each of the structures specified for each imaging plane.
2) Discuss the different pulse sequence designs used to illustrate the variable anatomic and physiologic information that can be displayed in each section.

I. Transaxial plane:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Transaxial plane:</th>
</tr>
</thead>
<tbody>
<tr>
<td>liver</td>
<td>left adrenal gland</td>
</tr>
<tr>
<td>spleen</td>
<td>colon</td>
</tr>
<tr>
<td>gallbladder</td>
<td>pancreas</td>
</tr>
<tr>
<td>inferior vena cava</td>
<td>right kidney</td>
</tr>
<tr>
<td>stomach</td>
<td>left kidney</td>
</tr>
<tr>
<td>descending aorta</td>
<td>portal vein</td>
</tr>
<tr>
<td>right adrenal gland</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>spleen</td>
<td>small bowel mesentery</td>
</tr>
<tr>
<td>liver</td>
<td>stomach</td>
</tr>
<tr>
<td>right kidney</td>
<td>hepatic vein</td>
</tr>
<tr>
<td>left kidney</td>
<td>inferior vena cava</td>
</tr>
<tr>
<td>vertebral column</td>
<td>renal arteries</td>
</tr>
</tbody>
</table>

II. Coronal plane:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Coronal plane:</th>
</tr>
</thead>
<tbody>
<tr>
<td>spleen</td>
<td>small bowel mesentery</td>
</tr>
<tr>
<td>liver</td>
<td>stomach</td>
</tr>
<tr>
<td>right kidney</td>
<td>hepatic vein</td>
</tr>
<tr>
<td>left kidney</td>
<td>inferior vena cava</td>
</tr>
<tr>
<td>vertebral column</td>
<td>renal arteries</td>
</tr>
</tbody>
</table>

III. Sagittal plane:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Sagittal plane:</th>
</tr>
</thead>
<tbody>
<tr>
<td>liver</td>
<td>spleen</td>
</tr>
<tr>
<td>abdominal aorta</td>
<td>stomach</td>
</tr>
<tr>
<td>kidney</td>
<td>pancreas</td>
</tr>
</tbody>
</table>

PELVIS IMAGING

The student will be able to:
1) Identify on the MR images of the structures specified for each imaging plane.
2) Discuss the different pulse sequence designs used to illustrate the variable anatomic and physiologic information that can be displayed in each section.

I. Transaxial plane:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Transaxial plane:</th>
</tr>
</thead>
<tbody>
<tr>
<td>sacrum</td>
<td>ischium</td>
</tr>
<tr>
<td>ilium</td>
<td>pubic symphysis</td>
</tr>
<tr>
<td>bladder</td>
<td>rectum</td>
</tr>
<tr>
<td>femoral head</td>
<td>bowel</td>
</tr>
<tr>
<td>greater trochanter</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>ovaries</td>
<td>seminal vesicles</td>
</tr>
<tr>
<td>uterus</td>
<td>prostate</td>
</tr>
<tr>
<td>cervix</td>
<td>penis</td>
</tr>
<tr>
<td>vagina</td>
<td>spermatic cord</td>
</tr>
<tr>
<td>clitoris</td>
<td>testicle</td>
</tr>
</tbody>
</table>

II. Coronal plane:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Coronal plane:</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetabulum</td>
<td>iliac bone</td>
</tr>
<tr>
<td>femoral head</td>
<td>inferior vena cava</td>
</tr>
<tr>
<td>abdominal aorta</td>
<td>sacroiliac joint</td>
</tr>
<tr>
<td>bladder</td>
<td>symphysis pubis</td>
</tr>
<tr>
<td>psoas muscle</td>
<td>greater trochanter</td>
</tr>
</tbody>
</table>
EXTREMITES IMAGING
The student will be able to:
1) Identify on the MR image each of the structures specified for each imaging plane.
2) Discuss the different pulse sequence designs used to illustrate the variable anatomic and
   physiologic information that can be displayed in each section.

Shoulder
I. Transaxial plane:
   - humeral head
   - clavicle
   - spine of scapula
   - glenohumeral joint
   - coracoid process
   - humerus
   - glenoid fossa

II. Coronal plane:
   - clavicle
   - acromion process
   - acromioclavicular joint
   - rotator cuff

III. Sagittal plane:
   - humeral head
   - acromion
   - rotator cuff
   - clavicle
   - glenoid fossa

Elbow Joint
I. Transaxial plane:
   - humerus
   - lateral epicondyle
   - medial epicondyle
   - trochlea
   - olecranon
   - radial head
   - ulna
   - radius

II. Coronal plane:
   - humerus
   - radius
   - ulna

III. Sagittal plane:
   - humerus
   - radius
   - ulna
### Wrist Joint

**I. Transaxial plane:**
- radius
- ulna
- tendons
- navicular (scaphoid)
- hamate

- greater multangular (trapezium)
- lesser multangular (trapezoid)
- metacarpals
- lunate
- capitate
- pisiform
- hook of hamate

**II. Coronal plane:**
- radius
- ulna
- navicular
- lunate

- triquetrum
- pisiform
- greater multangular
- metacarpals
- capitate
- hamate

**III. Sagittal plane:**
- radius
- ulna

- carpals
- metacarpals
- phalanges

### Hip Joint

**I. Transaxial plane:**
- ischium
- femoral head
- acetabulum

- greater trochanter
- pubic symphysis
- neck of femur
- ischial tuberosity

**II. Coronal plane:**
- ilium
- acetabulum
- femoral head

- iliac crest
- greater trochanters
- lesser trochanters
- psoas muscle

**III. Sagittal plane:**
- ilium
- acetabulum
- femoral head

- femur
- anterosuperior iliac spine
- ischial tuberosity

### Knee Joint

**I. Transaxial plane:**
- patella
- distal femur
- lateral femoral condyle

- medial femoral condyle
- anterior cruciate ligament
- infrapatellar fat
- posterior cruciate ligament
- tibial collateral ligament (medial)
- tibial collateral ligament (lateral)

**II. Coronal plane:**
- tibia
- fibula
- patella
- femur

- lateral meniscus
- anterior cruciate ligament
- posterior cruciate ligament
- tibial spine

**III. Sagittal plane:**
- femur
- patella
- tibia

- lateral femoral condyle
- infrapatellar fat pad
- anterior and posterior horns
- articular cartilage
- anterior cruciate ligament
- posterior cruciate ligament

- medial meniscus:
- anterior and posterior horns
Foot/Ankle Joint

I. Transaxial plane:
- tibia
- fibula
- lateral malleolus
- medial malleolus
- talus
- calcaneus
- tarsals
- metatarsals
- phalanges
- sesamoids

II. Coronal plane:
- tibia
- talus
- fibula
- lateral malleolus
- calcaneus
- metatarsals
- medial malleolus
- tarsals

III. Sagittal plane:
- tibia
- talus
- fat pad
- navicular
- lateral cuneiform
- cuboid
- intermediate cuneiform
- fibula
- lateral malleolus
- metatarsals
- phalanges
- sesamoid

The student will also be able to discuss the various disease processes in the following systems and explain how the MR image is effected by these processes:

A. Nervous system
B. Respiratory system
C. Cardiovascular system
D. Digestive system
E. Reproductive system
F. Musculoskeletal system

Required Assessments:
Assessment Names and Descriptions: Attendance:
100% class participation is extremely important. Due to the unique scheduling of this course, missing even one session is synonymous to missing three full weeks of class. Therefore anyone missing more than one class session will be required to withdraw.

Should it be necessary to miss a class session, prior arrangements must be made with the Assistant Program Director. The student will also be required to make up the session by completing an additional (fourth) observation day at a MRI facility (including report). It is the student’s responsibility to pursue all of the arrangements with the Assistant Program Director.

Students attending every class session will have their lowest test grade dropped before the computation of the final average.

Testing Procedures:
Take-home tests will follow the completion of each class session. Every test must be completed by each individual student. Each test will be due no later than the beginning of class on the date specified on the exam. A mock registry exam will be given online on the last day of the course.

Field Work:
Three 8-hour days of MRI clinical observation are required of each student. This is to be done at an approved facility chosen by the student. The first of these observation days must be completed prior to the second class session. The other days must be completed by the date specified. The MRI site supervisor/technologist must
verify attendance by their signature and a brief written report of each observation day is to be submitted by each student. This is necessary for course completion.

CSLO/Assessment Alignment:

<table>
<thead>
<tr>
<th>Course</th>
<th>CSLO 1</th>
<th>CSLO 2</th>
<th>CSLO 3</th>
<th>CSLO 4</th>
<th>CSLO 5</th>
<th>CSLO 6</th>
<th>CSLO 7</th>
<th>CSLO 8</th>
<th>CSLO 9</th>
<th>CSLO 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI 200</td>
<td>Physics Test 1, final exam</td>
<td>Physics Test 1, final exam</td>
<td>Physics Test 2, final exam</td>
<td>Physics Test 2, final exam</td>
<td>Physics Test 3, final exam</td>
<td>Physics Test 3, final exam</td>
<td>Physics Test 3, final exam</td>
<td>Physics Test 4, final exam</td>
<td>Physics Test 4, final exam</td>
<td>Physics Test 4, final exam</td>
</tr>
<tr>
<td>CSLO 11</td>
<td>CSLO 12</td>
<td>CSLO 13</td>
<td>CSLO 14</td>
<td>CSLO 15</td>
<td>CSLO 16</td>
<td>CSLO 17</td>
<td>CSLO 18</td>
<td>CSLO 19</td>
<td>CSLO 20</td>
<td></td>
</tr>
<tr>
<td>Physics Test 4, final exam</td>
<td>Physics Test 5, final exam</td>
<td>Physics Test 5, final exam</td>
<td>Anatomy test 1-5, final exam</td>
<td>Anatomy test 1-5, final exam</td>
<td>Anatomy test 1-5, final exam</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

1. 100% of the mean average of the ten take-home examinations. Total mastery level average must be 90% or greater to be eligible for the course certificate of completion. The grading policy employed will be as specified in the college catalog.
   
   A = 90-100
   B = 80-89
   C = 70-79
   D = 60-65
   F = 64 or below