



# Magnetic Resonance Imaging

The purpose of the ~~magnetic resonance imaging (MRI)~~ examination ~~requirement~~ is to assess ~~whether individuals have obtained~~ the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required ~~in of MRI technologists for practice~~ at entry ~~level into the profession~~. The tasks typically performed were determined by administering a comprehensive practice analysis survey to a nationwide sample of MR<sup>+</sup> technologists.<sup>1</sup> The *Task Inventory for Magnetic Resonance Imaging* may be found on the ARRT's website ([www.arrt.org](http://www.arrt.org)).

The *Examination Content Specifications for Magnetic Resonance Imaging* and ~~attached content outline~~ identify the knowledge areas underlying performance of the tasks on the *Task Inventory for Magnetic Resonance Imaging*. Every content category can be linked to one or more tasks on the task inventory.

ARRT avoids content when there are multiple resources with conflicting perspectives. Educational programs accredited by a mechanism acceptable to ARRT offer education and experience beyond the minimum requirements specified in the content specifications and clinical requirements documents.

This document is not intended to serve as a curriculum guide. Although ARRT programs for certification and registration and educational programs may have related purposes, their functions are clearly different. Educational programs are generally broader in scope and address the subject matter that is included in these content outline, but do not limit themselves to only this content.

The table below presents the major content categories and subcategories covered on the examination. The number of test questions in each category are listed in bold and number of test questions in each subcategory in parentheses. Specific topics within each category are addressed in the content outline, which makes up the remaining pages of this document.

Content Category	Number of Scored Questions <sup>2</sup>
Patient Care	<b>4816</b>
<i>Patient Interactions and Management</i> <del>(18)</del> (16)	
Safety	<b>2021</b>
<i>MR<sup>+</sup> Screening and Safety</i> <del>(20)</del> (21)	
Image Production	<b>105106</b>
<i>Physical Principles of Image Formation</i> <del>(39)</del> (40)	
<i>Sequence Parameters and Options</i> (36)	
<i>Data Acquisition, Processing, and Storage</i> (30)	
Procedures	<b>57</b>
<i>Neurological</i> (25)	
<i>Body</i> (15)	
<i>Musculoskeletal</i> (17)	
<b>Total</b>	<b>200</b>

<sup>1</sup> A special debt of gratitude is due to the hundreds of professionals participating in this project as committee members, survey respondents, and reviewers.

<sup>2</sup> The exam includes an additional ~~20~~30 unscored (pilot) questions.



## Patient Care

### 1. Patient Interactions and Management

#### A. Ethical and Legal Aspects

1. patients' rights
  - a. informed consent  
(\*e.g., written, oral, implied)
  - b. confidentiality (HIPAA)
  - c. American Hospital Association (AHA) Patient Care Partnership (Patients' Bill of Rights)
    1. privacy
    2. extent of care (e.g., DNR)
    3. access to information
    4. living will, health care proxy, advance directive
    5. research participation
2. legal issues
  - a. verification (e.g., patient identification, compare order to clinical indication, **exam coding**)
  - b. common terminology (e.g., battery, negligence, malpractice, beneficence)
  - c. legal doctrines (e.g., respondeat superior, res ipsa loquitur)
  - d. restraints versus **positioning aids** **immobilization used to eliminate motion artifact**
3. ARRT Standards of Ethics

#### B. Interpersonal Communication

1. modes of communication
  - a. verbal/written
  - b. nonverbal (e.g., eye contact, touching)
2. challenges in communication
  - a. interactions with others
    1. language barriers
    2. cultural and social factors
    3. physical-~~of~~, sensory, or **cognitive** impairments
    4. age
    5. emotional status, acceptance of condition  
(e.g., **mental health concerns**)
  - b. explanation of medical terms
  - c. strategies to improve understanding

3. patient education
  - a. explanation of current procedure (e.g., purpose, exam length, **risks, benefits**)
  - b. pre- and post-procedure instructions (e.g., preparations, diet, medications, discharge instructions)
  - c. **review of pertinent medical history**
  - ~~ed.~~ respond to inquiries about other imaging modalities
  - ~~ee.~~ communication with patient during procedure
- C. Physical Assistance and Monitoring
  - ~~1.~~ **patient transfer and movement**
    - ~~1.a.~~ body mechanics (e.g., balance, alignment, movement)
    - ~~ba.~~ patient transfer techniques
    - ~~b.~~ **safe patient handling devices** (e.g., **transfer board**)
  2. assisting patients with medical equipment
    - a. infusion catheters and pumps
    - b. oxygen delivery systems
    - c. other (e.g., nasogastric tubes, urinary catheters, tracheostomy tubes)
  3. routine monitoring **and documentation**
    - a. vital signs
    - b. physical signs and symptoms (e.g., **motor control, severity of injury**)
    - c. fall prevention
    - d. ~~documentation~~ **patient comfort and privacy**
    - e. sedated patients/**sedation**
    - f. claustrophobic patients
    - ~~g.~~ **time-out**
- D. Medical Emergencies
  1. allergic reactions (e.g., contrast media, latex)
  2. cardiac/respiratory arrest (e.g., CPR, **AED**)
  3. physical injury, trauma, or RF burn
  4. other medical disorders (e.g., seizures, diabetic reactions)
  5. **communication of critical findings to health care team**

\* The abbreviation "e.g.," is used to indicate that examples are listed in parenthesis, but that it is not a complete list of all possibilities.

(Patient Care continues on the following page.)



## Patient Care (continued)

### E. Infection Control

1. chain of infection (cycle of infection)
  - a. pathogen
  - b. reservoir
  - c. susceptible host
  - d. portal of entry
  - e. mode of transmission
    1. direct
      - a. droplet
      - b. direct contact
    2. indirect
      - a. airborne
      - b. vehicle-borne (fomite)
      - c. vector-borne (mechanical or biological)
  - f. portal of exit
2. asepsis
  - a. equipment disinfection
  - b. equipment sterilization
  - c. medical aseptic technique
  - d. sterile technique
3. CDC Standard Precautions
  - a. hand hygiene
  - b. use of personal protective equipment (PPE) (e.g., gloves, gowns, masks)
  - c. safe handling of contaminated equipment and surfaces
  - d. disposal of contaminated materials
    1. linens
    2. needles
    3. patient supplies
    4. blood and body fluids
  - e. safe injection practices
4. transmission-based precautions
  - a. contact
  - b. droplet
  - c. airborne
5. additional precautions
  - a. neutropenic precautions (reverse isolation)
  - b. healthcare associated (nosocomial) infections

### F. Handling and Disposal of Toxic or Hazardous Material

1. types of materials
  - a. chemicals (e.g., disinfectants)
  - b. chemotherapy
2. safety data sheet (e.g., material safety data sheets)

### G. Pharmacology

1. patient history
  - a. medication reconciliation (current medications)
  - b. premedications
  - c. contraindications
  - d. scheduling and prioritizing sequencing examinations
2. administration
  - a. routes (e.g., IV, oral)
  - b. supplies (e.g., needles)
  - c. procedural technique (e.g., venipuncture)
  - d. dose calculation
  - e. power injector
    1. fluoro-triggering
    2. timing bolus
    3. automatic bolus tracking
3. contrast media types and properties (e.g., gadolinium, linear versus macrocyclic, ionic versus non-ionic)
4. appropriateness of contrast media to examination
  - a. patient condition
  - b. patient age and weight
  - c. laboratory values (e.g., BUN, creatinine, eGFR)
5. complications/reactions
  - a. local effects (e.g., extravasation/infiltration, phlebitis)
  - b. systemic effects
    1. mild
    2. moderate
    3. severe
  - c. emergency medications
  - d. technologist's response and documentation



## Safety

### 1. MRI Screening and Safety

#### A. Screening and Education

(patients, personnel, non-personnel)

1. biomedical implants (**active, passive**)
  - a. identify and document device, year, make, model
  - b. research and verify device labeling (MR **S**safe, MR **C**conditional, MR **U**unsafe)
  - c. identify device specific parameters
  - ~~d. scanning conditional implants~~
2. ferrous foreign bodies
3. medical conditions (e.g., pregnancy)
4. prior diagnostic or surgical procedures
5. topical or externally applied items (e.g., tattoos, medication patches, body piercing jewelry, monitoring devices, clothing)
6. **L**level 1 and **L**level 2 MRI personnel

#### B. Electromagnetic Fields

1. static field
  - a. translational and rotational forces
  - b. magnetohydrodynamic effect
  - c. magnetohemodynamic effect
  - d. magnetic shielding
  - e. spatial gradient of the static magnetic field
  - f. FDA guidelines
2. ~~radiofrequency (RF)~~ field
  - a. thermal heating (**specific absorption rate [SAR]**)
  - b. conductive loops
  - c. proximity burns
  - d. RF shielding
  - e. FDA guidelines
3. gradient field
  - a. current induction
  - b. acoustic noise
  - c. peripheral neurostimulation
  - d. magnetophosphenes
  - e. FDA guidelines

#### C. Equipment

1. placement of conductors (e.g., ECG leads, coils, cables)
2. cryogen safety
3. ancillary equipment (MR **S**safe, MR **C**conditional, MR **U**unsafe)

#### D. Environment

1. climate control (temperature, humidity)
2. designated MR safety zones
3. gauss lines
4. emergency procedures (e.g., quench, fire)



## Image Production

### 1. Physical Principles of Image Formation

#### A. Instrumentation

1. electromagnetism  
(e.g., Faraday's law)
2. static magnet
  - a. types (superconductive, resistive, permanent)
  - b. magnetic field strength
  - c. shim coils
3. RF system
  - a. coil configuration
  - b. surface coils
  - c. phased array coils
  - d. transmit and receive coils
  - e. transmit and receive bandwidth
  - f. pulse profile
4. gradient system
  - a. gradient coil configuration
  - b. slew rate
  - c. rise time
  - d. duty cycle

#### B. Fundamentals

1. nuclear magnetism
  - a. Larmor equation
  - b. precession
  - c. gyromagnetic ratio
  - d. resonance
  - e. RF pulse
  - f. equilibrium magnetization
  - g. energy state transitions
  - h. phase coherence
  - i. free induction decay (FID)
  - j. magnetic susceptibility  
(e.g., diamagnetism, paramagnetism, superparamagnetism, ferromagnetism)
2. tissue characteristics
  - a. T1 recovery
  - b. T2 decay (relaxation)
  - c. T2\* (susceptibility)
  - d. proton (spin) density (PD)
  - e. flow
  - f. diffusion
  - g. perfusion

#### 3. spatial localization

- a. vectors
- b. X, Y, Z coordinate system
- c. physical gradient
- d. slice select gradient
- e. phase-encoding gradient
- f. frequency (readout) gradient
- g. sampling frequency/rate
- h. k-space (raw data)

#### C. Artifacts (Cause, Appearance, and Compensation)\*\*

1. aliasing ([wrap around](#))
2. Gibbs, truncation
3. chemical shift
4. chemical misregistration
5. magnetic susceptibility
6. radiofrequency (e.g., zipper)
7. motion and flow  
(e.g., patient motion, ghosting)
8. partial volume averaging
9. cross-talk
10. cross-excitation
11. moiré pattern
12. parallel imaging artifacts
13. eddy currents
14. dielectric effect

#### D. Quality Control

1. slice thickness
2. spatial resolution
3. contrast resolution
4. signal to noise
5. center frequency
6. transmit gain
7. geometric accuracy
8. equipment inspection  
(e.g., coils, cables, door seals)

\*\* The subsequent list of artifacts is not a complete list of all possibilities.

(Image Production continues on the following page.)



## Image Production (continued)

### 2. Sequence Parameters and Options

- A. Imaging Parameters
  - 1. repetition time (TR)
  - 2. echo time (TE)
  - 3. inversion time (TI)
  - 4. number of signal averages (NSA, NEX)
  - 5. flip angle (e.g., Ernst angle)
  - 6. field of view (FOV)
  - 7. matrix
  - 8. pixel
  - 9. voxel
  - 10. number of slices
  - 11. slice thickness and gap
  - 12. phase and frequency
  - 13. echo train length (ETL)
  - 14. effective TE
  - 15. bandwidth (transmit, receive)
  - 16. concatenations (number of acquisitions per TR)
  - 17. b-value
  - 18. velocity encoding (VENC)
- B. Image Contrast
  - 1. T1 weighted
  - 2. T2 weighted
  - 3. PD weighted
  - 4. T2\* weighted
  - 5. diffusion weighted imaging (DWI)
  - 6. susceptibility weighted imaging (SWI)
- C. Imaging Options
  - 1. 2D and 3D
  - 2. slice order (sequential, interleaving)
  - 3. spatial saturation pulse/band
  - 4. gradient moment nulling
  - 5. suppression techniques (e.g., fat, water, Dixon method)
  - 6. physiologic gating and triggering
  - 7. in-phase and out-of-phase
  - 8. rectangular FOV
  - 9. anti-aliasing
  - 10. parallel imaging
  - 11. filtering

### FOCUS OF QUESTIONS:

Questions will address the interdependence of the imaging parameters, weightings, and options listed on the left, and how they affect image quality.

#### Image Quality

- contrast to noise ratio (CNR, C/N)
- signal to noise ratio (SNR, S/N)
- spatial resolution
- acquisition time

(Image Production continues on the following page.)



## Image Production (continued)

### 3. Data Acquisition, Processing, and Storage

#### A. Pulse Sequences

1. spin echo (SE)
  - a. conventional spin echo
  - b. fast spin echo (FSE)
2. inversion recovery (IR)  
(e.g., STIR, FLAIR)
3. gradient echo (GRE)
  - a. conventional gradient echo
  - b. spoiled gradient echo
  - c. coherent gradient echo
  - d. steady state free precession (SSFP)
  - e. fast gradient echo
  - f. MRA/MRV
    1. flow dynamics
    2. time-of-flight (TOF)
    3. phase contrast
    4. contrast enhanced
4. echo planar imaging (EPI)
5. diffusion weighted imaging (DWI)
6. susceptibility weighted imaging (SWI)
7. perfusion
8. spectroscopy

#### B. Data Manipulation

1. k-space mapping and filling  
(e.g., centric, spiral, keyhole)
2. fast Fourier transformation (FFT)
3. Nyquist theorem
4. post-processing
  - a. maximum intensity projection (MIP) reformation
  - b. multiplanar reformation (MPR)
  - c. subtraction
  - d. apparent diffusion coefficient (ADC) mapping
  - e. CINE

#### C. Informatics

1. hard/electronic copy  
(e.g., DICOM file format)
2. archive
3. PACS and electronic medical record (EMR)
4. security and confidentiality
5. networking



## Procedures

### 1. Neurological

#### A. Head and Neck

1. brain
2. brain for MS
3. brain for seizure
4. infant brain (less than one year old)
5. brain perfusion
6. ~~brain for~~ CSF flow
7. brain spectroscopy
8. IACs
9. pituitary
10. orbits
11. cranial nerves (non-IACs)
12. sinuses
13. soft tissue neck  
(e.g., parotids, thyroid)
14. vascular head (MRA)
15. vascular head (MRV)
16. vascular neck

#### B. Spine

1. cervical
2. thoracic
3. lumbar
4. sacroiliac (SI) joints
5. sacrum-coccyx
6. ~~whole~~total spine
7. lumbar plexus

### FOCUS OF QUESTIONS

Questions about each of the studies listed on the left may focus on any of the following factors:

#### Anatomy and Physiology

- imaging planes
- pathological considerations
- protocol considerations
- patient considerations  
(e.g., pediatric, geriatric, bariatric, trauma)

#### Patient Set-Up

- patient data input
- coil selection and position
- patient orientation
- landmarking
- physiologic gating and triggering

#### Contrast Media

- effect on images

#### Additional Procedures

- CINE (e.g., CSF flow study, TMJs)
- surgical planning

~~(Procedures continue on the following page.)~~





## Procedures (continued)

### 2. Body

- A. Thorax
  - 1. chest (noncardiac)
  - 2. breast
  - 3. vascular thorax
  - 4. brachial plexus
- B. Abdomen
  - 1. liver
  - 2. pancreas
  - 3. spleen
  - 4. adrenals
  - 5. kidneys
  - 6. enterography
  - 7. vascular abdomen (MRA, MRV)
  - 9. MRCP
- C. Pelvis
  - 1. soft tissue pelvis (e.g., bladder, rectum)
  - 2. female soft tissue pelvis (e.g., uterus)
  - 3. male soft tissue pelvis (e.g., prostate)
  - 4. vascular pelvis (MRA, MRV) (e.g., femoral, iliac)

### 3. Musculoskeletal

- A. Temporomandibular Joints (TMJs)
- B. Sternum
- C. Sternoclavicular (SC) Joints
- D. Shoulder
- E. Long Bones (upper extremity)
- F. Elbow
- G. Wrist
- H. Hand
- I. Fingers (non-thumb)
- J. Thumb
- K. Bony Pelvis
- L. Hip
- M. Long Bones (lower extremity)
- N. Knee
- O. Ankle
- P. Foot
- Q. Arthrogram
- R. Vascular Extremities (e.g., runoff MRA)
- S. Soft Tissue

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