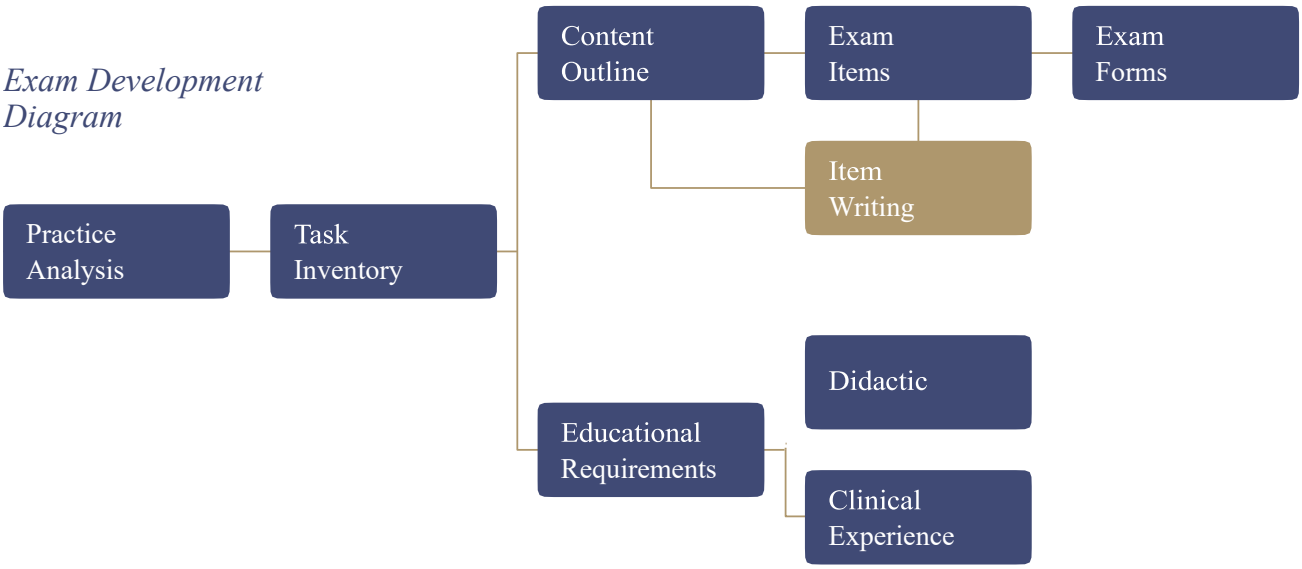
The American Registry of Radiologic Technologists®

Item Writing Manual

Exam Development Diagram



Promoting high standards of patient care by recognizing qualified individuals in medical imaging, interventional procedures, and radiation therapy.

The American Registry of Radiologic Technologists® Item Writing Manual

Authored by:
ARRT Examination Requirements and Psychometrics

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1255 Northland Drive
St. Paul, Minnesota 55120
Telephone: 651.687.0048
Visit our website: www.arrt.org

Forward

ARRT is the largest credentialing agency for radiologic technologists, offering certification and registration in radiography, nuclear medicine technology, radiation therapy, mammography, computed tomography, magnetic resonance imaging, sonography, vascular sonography, bone densitometry, cardiac interventional radiography, vascular interventional radiography, breast sonography, and radiologist assistant. More than 350,000 individuals hold a certification in ARRT's categories.

The quality of ARRT's certification and registration programs is supported by three pillars known as the Equation for Excellence. Education is the first of the three pillars and applies throughout an R.T.'s career. Candidates must meet the didactic and clinical requirements for initial eligibility and will continue to meet ongoing education requirements to maintain their certification and registration. The second pillar – ethics – provides proactive guidance on what it means to be qualified and to motivate and promote a culture of ethical behavior within the profession. Finally, ARRT's state-of-the-art examinations serve as the third pillar and act as the final step for a candidate to demonstrate that they have the knowledge and skills necessary for initial certification and registration in their discipline.

ARRT bases all testing programs on the results of a comprehensive practice analysis that establishes the knowledge and skills typically required to practice in the discipline. Then, ARRT psychometricians and exam development coordinators work with subject matter experts from the field to create exam questions (also known as items) and tests (also known as forms) that measure those knowledge and skills.

ARRT's attention to detail is perhaps best exemplified by its item-development process. Items are written by subject matter experts and designed with psychometrically proven formats that measure critical thinking and clinical problem-solving skills. This is why ARRT is sharing its psychometric expertise with you. As a team, we can help promote high standards of patient care by recognizing qualified individuals in medical imaging, interventional procedures, and radiation therapy.

Contents

Chapter 1 – Introduction

Some might wonder: "What is the big deal about writing multiple choice questions?" Just by having picked up this manual, you have demonstrated awareness that there are probably several big deals. By reading it, you will learn what they are and how to manage them.

Overview

This book presents guidelines for developing test items for ARRT examinations. While its primary audience is individuals who write questions for ARRT exams, the information may be useful to anyone who writes test questions. Chapters two and three cover the essentials of item writing: question format, editorial conventions, and stylistic considerations. Chapters four and five focus on strategies for producing test items. You will learn how to identify topics and then convert your knowledge of those topics into test items.

We believe that the best way to learn is by example. This guidebook includes sample test questions and other information. While we draw most examples from outdated content in the field of radiography, you will also find occasional examples from other disciplines.

The Purpose of Assessment

Tests can serve different purposes depending on the needs of the stakeholder. For the individual candidate, tests evaluate candidate progress toward achieving educational goals, identify areas that require remedial activity, assign grades, and determine scholarship recipients. At the institutional level, testing can be used to evaluate programs and identify strong or weak areas of the curriculum. Finally, at the state or national level, tests are often used to certify competence or to licence individuals for practice in an occupation or profession. ARRT's exams are designed for this last use case:

> *The purpose of the examination requirement is to assess whether individuals have obtained the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required in the discipline for practice at entry level.*

Let's look closer at three key phrases from this statement of purpose:

…assess whether individuals have obtained the knowledge and cognitive skills… Written exams are great for evaluating cognitive skills, but they do not tell us much about the clinical skills that a person performs in the work setting such as positioning a patient. What written exams can evaluate is knowledge related to positioning: what the position is called, what it is used for, what it looks like, and so on. If you see this as a limitation of written exams, you are right! In fact, this very limitation is one of the reasons behind ARRT's clinical competency and experience requirements.

…underlying the intelligent performance… Some test items require candidates simply to recognize facts and basic concepts. But others go deeper — requiring candidates to understand why certain things are done, how to apply principles to clinical practice, and how to adapt to unusual circumstances. Only the most carefully crafted items can get at these types of critical thinking skills.

…of the tasks typically required… ARRT exams are related to practice. If an activity or procedure is not required in practice, then the related knowledge should not be covered on the exam. This is why many of the topics covered in common textbooks are not addressed by ARRT exams.

Exam Content and Length

Each ARRT certification and registration exam is built on a Task Inventory (TI) and detailed Content Outline (CO) (A.K.A. Content Specification [CS]). The TI is determined by surveying a national sample of practitioners to determine what constitutes typical practice. The CO identifies the knowledge required to perform the tasks and serves as a blueprint for developing the exam. Although ARRT exams and educational curricula cover many of the same subjects, certification and registration exams are more focused on actual practice. The ARRT exams do not cover everything that an educational program does.

RADIOGRAPHY EXAMINATION
TASK INVENTORY

ARRT® BOARD APPROVED: **JULY 2015**
IMPLEMENTATION DATE: **JANUARY 2017**

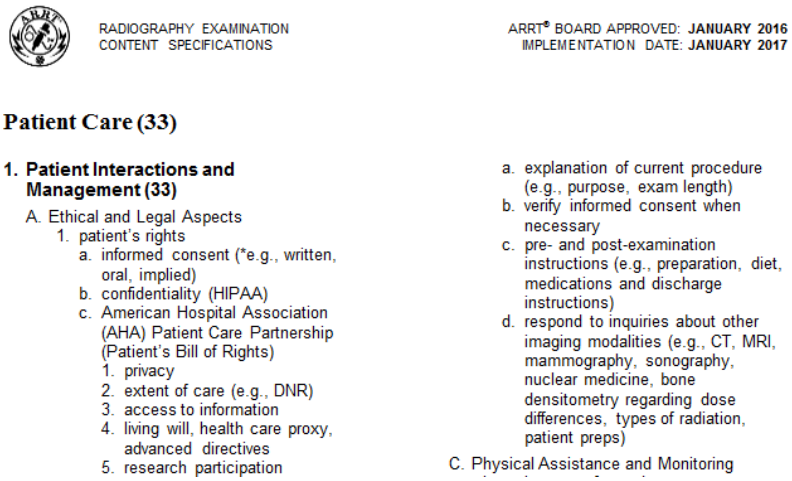
Activity		Content Categories Legend: PC = Patient Care, S = Safety, IP = Image Production, P = Procedures
1.	Confirm patient's identity.	PC.1.A.2.A., PC.1.B.
2.	Evaluate patient's ability to understand and comply with requirements for the requested examination.	PC.1.B.
3.	Obtain pertinent medical history.	PC.1.A.2.A., PC.1.B., PC.1.G.1.A.
4.	Manage complex interpersonal interactions within the workplace in an effective manner.	PC.1.B.2.
5.	Explain and confirm patient's preparation (e.g., diet restrictions, preparatory medications) prior to beginning imaging examinations.	PC.1.B.3.C.

Figure 1. Example of task inventory mapped to content specifications

The number of questions on ARRT exams varies considerably by area of practice. Most well-constructed exams are developed according to the "domain sampling model." No single exam covers all topics in a field; rather, they represent a sample of those topics. Studies have shown that candidates taking a test with 150 to 200 questions get a score almost identical to what they would obtain on a more exhaustive test of 300 questions. (Crocker & Algina 1986, Ch. 7)

ARRT's postprimary exams typically have fewer items than primary exams. For example, the Mammography exam does not cover topics such as radiation protection and basic patient care, because they were already covered on the prerequisite Radiography exam. Some exams are shorter than others because scopes of practice are much more focused. Exams in areas such as Bone Densitometry require fewer items than exams in MRI or Vascular Interventional Radiography.

There are content categories outlined for every ARRT examination. The content areas are derived from the task lists. A panel of subject matter experts determines the knowledge required to perform a task on the task list. Then, once the content has been determined, that same panel determines the number of items in each content area.



RADIOGRAPHY EXAMINATION
CONTENT SPECIFICATIONS

ARRT® BOARD APPROVED: **JANUARY 2016**
IMPLEMENTATION DATE: **JANUARY 2017**

Patient Care (33)

1. Patient Interactions and Management (33)

A. Ethical and Legal Aspects
1. patient's rights
a. informed consent (*e.g., written, oral, implied)
b. confidentiality (HIPAA)
c. American Hospital Association (AHA) Patient Care Partnership (Patient's Bill of Rights)
1. privacy
2. extent of care (e.g., DNR)
3. access to information
4. living will, health care proxy, advanced directives
5. research participation

a. explanation of current procedure (e.g., purpose, exam length)
b. verify informed consent when necessary
c. pre- and post-examination instructions (e.g., preparation, diet, medications and discharge instructions)
d. respond to inquiries about other imaging modalities (e.g., CT, MRI, mammography, sonography, nuclear medicine, bone densitometry regarding dose differences, types of radiation, patient preps)

C. Physical Assistance and Monitoring

Figure 2. Content specifications excerpt

Why The Multiple Choice Format?

ARRT exams use multiple choice questions (MCQs). These are also known as selected-response items, because candidates choose an answer from several that are provided. Essay, short-answer, and practical exams, on the other hand, are referred to as constructed-response tests. Candidates must actually create the answer.

In some cases, MCQs are not the best assessment option. For example, since we know we cannot assess practical skills with MCQs, the ARRT relies on clinical instructors or program directors who observe candidates in the practice setting.

But most of the limitations to MCQs can be addressed. It is possible to write items that assess in-depth knowledge. It is possible to have technically accurate items that are clearly written at the appropriate reading level. And it is possible to write test items without conveying extraneous clues that benefit test wise candidates.

That is the purpose of this guidebook: to help item writers capitalize on the benefits of MCQs, while minimizing the limitations.

Table 1. Multiple choice Questions: Pros and Cons

Advantages	Disadvantages
Allow for broad content coverage: Many items can be presented and answered in a short period of time	Test for recognition instead of recall or the ability to arrive at answer without clues
Best for knowledge and cognitive skills	Cannot assess practical (clinical) or interpersonal skills
Easy to administer to large groups	Encourage MCQ study habits like rote memorization
Can compute statistics to help evaluate item quality	Scores can be contaminated by "testwiseness" and general reading skills
Objective scoring: Scores are very reliable	

Chapter 2 – Multiple Choice Questions

The prototypical multiple choice item asks a question, and the candidate must select one of four potential answers as their response. Multiple choice items are not strictly limited to this format and often include three to five potential answers. Furthermore, these items may be structured as a "fill-in-the-blank" or "complete the sentence" rather than a question. Consequently, we will use the term *item* rather than *question* throughout this manual when referring to a single scoreable unit of an exam.

Anatomy of an Item

There are four key definitions you will need to understand for the rest of this manual:

- The *stem* presents a question, problem, or situation that the candidate must respond to
- The *key* is the correct answer
- *Distractors* are plausible, but clearly incorrect answers
- *Options* refer to all possible answers to the stem, including both key and distractors

What is another name for the navicular? ← Stem

Options
- A. triquetrum
- B. semilunar
- C. cuneiform

Distractors

- D. scaphoid* ← Key (correct answer)

ARRT Item Formats

Two basic MCQ formats comprise the majority of items on ARRT's certification and registration examinations: direct question and incomplete statement. Adding tables, graphics, and other material can enhance both, as described later.

Direct Question

In the example below, the stem poses a single, complete problem, while each option provides a possible solution or answer. Item writers prefer this format for its ability to present a clearly formulated problem.

Which of the following refers to the degree of blackening seen on a radiograph?

A. radiographic intensity
B. radiographic contract
C. radiographic sharpness
D. radiographic density*

MCQs typically consist of three, four, or five options. The more options candidates have, the less likely they are to simply guess the correct answer. It can be difficult to create five plausible options, and adding obvious incorrect answers does not increase an item's quality or difficulty. For our purposes, we will concentrate on MCQs with four options.

Incomplete Statement

The preceding example can also be written as an incomplete statement, a format that often results in fewer words. In this case, the word radiographic was deleted from each option and placed into the stem.

A. The degree of blackening seen on a radiograph is referred to as radiographic:
B. intensity
C. contrast
D. sharpness
E. density*

The key to writing a good incomplete statement is to have the stem relate a complete problem. It might be tempting to break a statement by inserting a colon (:) into the middle of it, and then to call it a stem, but you can end up with an item that is flawed, like the example below.

FLAWED ITEM: The degree of blackening seen on a radiograph:

A. must be controlled by the kVp setting
B. is called contrast
C. is frequently caused by scattered radiation
D. is referred to as radiographic density*

This example of an "unfocused stem" demonstrates the most common problem in item writing: not only does the stem fail to present a single problem, it also—because it lacks focus—encourages heterogeneous options, which tend to wander all over the place. Worse yet, a stem that does not present a well-defined problem makes it easier to end up with two correct answers (e.g., option C is partially correct because scatter can increase density).

A good way to tell if a stem is unfocused is to mask the options and ask whether a knowledgeable candidate could determine the answer by reading just the stem. If it is necessary to read all options to figure out what the stem is really asking, then the stem does not have ample information. An even better way to focus a stem is to first write it as a direct question, and then convert it to an incomplete statement—but only if there is good reason to do so, such as making the item easier to read. In general, if it is not possible to phrase a stem as a question, then the item is probably flawed.

Note that the previous examples contain only one correct answer, and the distractors are clearly incorrect. This is not so with a variation of the direct question and incomplete statement formats called "best answer." It offers alternatives that may be partially correct, with one being clearly more correct than the others. The best answer format is used to gauge complex achievement, such as asking a candidate to select the best reason for an action, the best method for doing something, or the best application of a principle. For example, an item on managing a skin reaction to radiation therapy might list several correct ways to treat erythema, but one of the methods may be better than the others. Best answer items usually require judgment and often involve opinions; you should use those when it is important for the candidate to know the best course of action.

Images and Exhibits

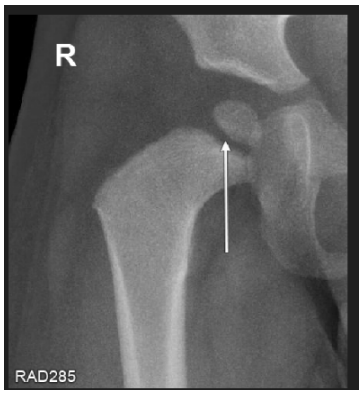
The incomplete statement and direct question formats serve as building blocks for items that display information in exhibits such as tables, graphs, text paragraphs, drawings, medical images, photographs, and videos. Exhibits can present information in a way that is practical, clinically relevant, and concise ("a picture is worth a thousand words"). They also provide an alternative way to assess critical thinking.

Given that radiologic science is mostly about medical imaging, it makes perfect sense to use radiographs, CT scans, sonograms, and other images for test items. Once you have gone to the trouble of producing an image, illustration, or video clip, it makes sense to write multiple items to go with it. The examples that follow demonstrate the different types of items that can accompany an image or illustration and show that drawings can go beyond simple identification of parts.

Keep in mind that most illustrations lend themselves to questions about both structure (e.g., anatomy) and function (e.g., physiology). For example, test items based on a diagram of an x-ray tube could require candidates to identify parts, state the materials they consist of, and explain how they work.

What is the arrow on RAD285 pointing to?

A. hip joint
B. epiphyseal plate
C. intertochanteric crest
D. fovea capitis



Which of the following errors caused the unacceptable image visualized on RAD298?

A. image receptor was positioned lengthwise
B. central ray was centered midway between outer canthus and EAM
C. midsagittal plane was not perpendicular to the image receptor
D. optimum kV was not used

Tables and graphs are another common type of exhibit. Even a list of words or paragraph of text might be considered an exhibit. The first example below highlights the advantages of using a table to organize information in the stem. Although this table provides numbers, tables can also be used to present text, such as a list. The second example below presents a table in the options. While not technically an exhibit, the table format does improve readability.

A bone densitometry scan of the lumbar spine produces the BMD measurements below. What might explain these results?

region	g/cm^2
L1	0.98
L2	0.92
L3	0.96
L4	1.01

A. osteoporosis
B. scoliosis
C. vertebral fracture at L1*
D. severe facet sclerosis at L2

Which of the following sets of technical factors will produce a radiograph with the greatest density?

	mA	msec	SID	kVp
A.	100	500	48”	80
B.	200	250	36”	76*
C.	125	125	40”	76
D.	500	100	40”	76

Table 2. Exhibit Examples

Type of Exhibit	**Knowledge and Skill Assessed**
Medical images, anatomical illustrations, positioning, photographs, or diagrams	Recognize anatomy, physiology, or pathology; identify positions and projections; recognize positioning errors; recognize good positioning/image quality; identify artifacts; evaluate image quality; compensate for poor images
Drawings or photographs of equipment and instrumentation	Recognize parts, explain how systems function, explain QC procedures, troubleshoot equipment, evaluate instrument settings
Drawings or models of scientific principles or processes (e.g., scattered radiation; dose-response curves)	Identify and label parts, infer relationships, determine words or equations that correspond to a model or curve
Tables or graphs with technical factors, technique charts, equipment specifications, results of QC tests	Evaluate technical factors, calculate certain results, interpret and evaluate QC data, draw inferences, interpret data and use charts (e.g., bone mineral density readings)

Multi-Select Items

Standard multiple choice items are best used to assess situations where there is one correct answer, or there is one option that is clearly better than the alternatives presented. However, there are real life circumstances where there may be multiple correct options, or where there are two or more components that are used to effectively solve a problem. In situations such as this, where there is more than one correct or acceptable option, you can use the multi-select item format. This item format asks the candidate to select two or more of the options and is scored as correct only if the candidate selects all correct options. The following illustrates the format of a multi-select item:

Which three of the following options are correct? (select three)

A. incorrect option
B. correct option*
C. correct option*
D. incorrect option
E. correct option*
F. incorrect option*

The candidate would get this item correct if they selected options B, C, and E. If they did not select all the correct options, or selected any of options A, D, or F, they would get the item incorrect. The following is an example of a multi-select item:

Electrolyte levels can be measured from which two of the following? (select two)

A. saliva
B. urine*
C. blood*
D. skin scraping
E. nasal secretions

The candidate would get this item correct if they selected options B and C; any other combination of responses would be an incorrect response.

As with standard multiple choice items, all options in multi-select items should be either completely correct, or totally incorrect. These items are best written with two or more correct options and at least two, but preferably more, incorrect options.

ARRT requires that you write items with multiple correct options in the multi-select format.

Sorted List Items

The sorted list item is effectively used when the goal is to place options in logical order (e.g., from MOST to LEAST). The correct answer to a sorted list item is a sequence that is in order from one extreme to the other. The sequence can represent distance (e.g., near to far), time (e.g., first to last), or some other ordered variable. The following is an example of a sorted list item:

Move the options from the unordered list on the left to create an ordered list on the right.

Place the structures in order from proximal to distal.

Unordered Options	Ordered Options
elbow shoulder hand wrist	

The way these items work during the testing session is that the candidate is presented with the left-hand column of unordered options, and the right-hand column is initially blank. The candidate then uses the mouse to click on options in the left-hand column and drag them to the correctly ordered position in the right-hand column.

To correctly answer this example item, the candidate would first use the mouse to click on "shoulder" in the left-hand column and drag it to the top position in the right-hand column. The candidate would then click on "elbow" and drag it to the second position in the right-hand column. They would then do the same with the options "wrist" and "hand."

Unordered Options	Ordered Options
	shoulder elbow wrist hand

The sorted list item is best used when there is a list of four or more options that form a well-defined sequence.

Negatively Worded Items

You have seen test items that use not, except, or other negative wording in the stem. Sometimes it makes perfect sense to write test items that emphasize what should not be done—such as when certain drugs or procedures are contraindicated, or when some action must be avoided because it could be harmful. Negative wording can result in flawed items, so ARRT uses these items sparingly. Consider the following examples:

All of the following will result in grid cut-off EXCEPT:

A. an off-center tube
B. a tube that is perpendicular to the lead strips
C. improper SID being used with a focused grid
D. grid motion being started before exposure is made*

Which of the following will NOT result in grid cut-off?

A. an off-center tube
B. a tube that is perpendicular to the lead strips
C. improper SID being used with a focused grid
D. grid motion being started before exposure is made

A major limitation of these examples is that quick readers may miss the negative phrasing and select an incorrect answer. To help prevent this type of oversight, always highlight the negative word in uppercase, (e.g., NOT). Another limitation is the tendency to end up with "double negatives." In the example, option C contains the negative "improper," which makes the items difficult to understand. The format is often so flawed that ARRT discourages its use.

Section Review

This chapter described several useful formats for assessing knowledge and skills in the radiologic sciences and other disciplines. The following table lists each format and offers a summary judgment. The next chapter discusses style and editorial guidelines for those formats that ARRT endorses.

Table 3. Acceptable Item Types

ARRT-Endorsed Item Type	**Description**
Direct question	Preferred
Items with exhibits	Preferred
Incomplete statement	Acceptable
Sorted list	Acceptable
Multi-select	Acceptable
Rarely Accepted	**Description**
Negatively worded	Acceptable only when necessary
Not Endorsed	**Description**
Multiple true/false	Not accepted for ARRT exams
Matching	Not accepted for ARRT exams
Combined-response (k-type)	Not accepted for ARRT exams
Others (fill in the blank, true/false, none of the above, all of the above)	Not accepted for ARRT exams

Chapter 3 – Guidelines for Item Development

This chapter is divided into three major sections. First, we cover some general guidelines for item writing. Next, we get into the components—the stem and the options. The section review pulls it all together into a handy checklist.

Before we start, a rule of thumb: MCQs usually present three, four, or five options. The more choices, the less likelihood of a guess being right. However, it can be difficult to come up with plausible choices for five-option and sometimes even four-option choices. In fact, studies show three or four options per item to be optimal. For our purposes, we ask you to write MCQs with four options. Three option MCQs are permissible when there are only three plausible options (e.g., increases, decreases, remains the same; or axial, coronal, sagittal).

General Guidelines

Here are six standards for item writers:

1. **Test important knowledge and skills**. Design each item to measure an important learning outcome. Keep the focus on the content of the item; resist the temptation to include irrelevant, obscure, or insignificant material in an attempt to increase the item's difficulty.
2. **Be up to date and correct**. Avoid referring to events in the immediate future; it all-too-soon becomes the past. Try to write items that are contemporary but would not appear dated in a few years.
3. **Provide sufficient information**. The stem of an item must contain sufficient information to enable the candidate to select the appropriate answer. A candidate should be able to read the stem and—with the proper knowledge—state the answer without looking at the options.
4. **Make distractors plausible**. All distractors must be logically consistent with the stem. Any that are silly or obviously incorrect will not help ARRT assess the candidate's knowledge.
5. **Avoid bias**. Items must avoid both the reality and appearance of bias on the basis of race, color, creed, religion, national origin, sex, marital status, status with regard to public assistance, familial status, disability, sexual orientation, gender identity, veteran status, age, or any other legally protected basis. Avoid using gendered pronouns such as "she/he" or "her/him" in items, unless it is clinically relevant. If you feel the specific pronoun is necessary, please discuss it with the EDC.
6. **Offer only one correct answer**. There can only be one correct, or clearly best, answer. An exception to this would be when writing multi-select items that state in the stem that the candidate must select two or more answers.

Writing the stem

Set the task

A stem must provide sufficient information for the candidate to be able to interpret the item's intent and select the appropriate answer. Candidates should not have to read all the options to figure out what you are asking for. Check the clarity and completeness of the stem by covering the options and determining whether the candidate could answer the item without them.

Make it clear

Avoid ambiguous, confusing, or vague wording. The only reason to include superfluous material would be if you were testing whether candidates can identify relevant information. Test items are supposed to allow candidates to show what they have learned. If an item's wording, vocabulary, or sentence structure is confusing and prevents candidates from understanding what they are being asked, they would not have that opportunity.

Examine the two items below:

> According to the NCRP, the occupational dose-equivalent limit to a pregnant radiographer should NOT exceed how many rem during the gestation period?
>
> A. 0.3 rem
> B. 0.5 rem
> C. 1.0 rem
> D. 5.0 rem
>
> The primary purpose of the x-ray performance standards specified by Title 21 of the Code of Federal Regulations (part 1020) is to regulate:
>
> A. maximum patient exposure to x rays
> B. the design and manufacture of x-ray systems
> C. radiologic terminology
> D. radiographer knowledge and skill requirements

These examples share one fundamental fault: They are clunky due to awkward sentence structure, confusing wording, or vague terms.

The first item's unusual sentence construction plus use of the negative equals confusion. This item is testing relatively basic information, which can best be approached with a simple straightforward question: "According to the NCRP, what is the occupational dose-equivalent limit (in rem) for a pregnant radiographer?"

An ambiguous term in the second example is likely to cause candidates to stumble. What does the word "primary" mean? Could not one make a case for each one being "primary" in some way? You must clarify words like "best," "worst," "most important," and "greatest." Supply additional information that answers the question, "In terms of what?" The stem may be simplified by saying this, instead: "Which of the following does Part 1020, Title 21 of the Code of Federal Regulations address?"

Referencing documents

Nationally recognized authoritative documents are often listed as part of the Content Outline. Some examples are HIPAA, NCRP for radiology and radiation therapy, or MQSA for mammography. If a document is listed in the Content Outline, you may write items that ask about them (see example below).

Which of the following dictates how often a compression check must be done?

A. OSHA
B. NCRP
C. MQSA
D. ACR

If the document is in the stem, "according to…" usually works the best. Items written in this way should have the document listed in the Content Outline. The document may also be listed in the options. The key should be a document that can be found in the Content Outline.

Target appropriate level of reading difficulty

Item difficulty is dramatically influenced by vocabulary level—and our purpose is to test a candidate's knowledge level, not their vocabulary. Even a simple idea can be encased in vocabulary that very few candidates would understand. Notice that the third example is much clearer:

- The postulation of capillary effectuation promotes elucidation of how pliant substances ascent in incommodious veins
- The thesis of capillary execution serves to illuminate how fluids are elevated in small tubes
- The principle of capillary action helps explain how liquids rise in small passages

Clearly, vocabulary level—as well as sentence structure—has a major influence on whether candidates will understand what is being asked in a test question. Simple, declarative sentences work best.

Keep it short but not too short

State the stem as precisely as possible and steer clear of unnecessarily complex wording and sentence structure. A stem should present a complete problem. Examine the items below:

POOR ITEM: The navicular

A. is sometimes used as another name for scaphoid*
B. can be located in a patient's skull
C. is a small bone found in the knee
D. is a blood vessel

BETTER ITEM: What is another name for the navicular?

A. triquetrum
B. semilunar
C. scaphoid*
D. cuneiform

The "poor" stem fails to clearly set a problem. What bit of knowledge is this item intending to assess? Before you write an item, you must first have a very clear idea of what knowledge you are trying to assess. A candidate would have no idea what question is being asked. Only after reading the stem with all of the options does its point become clear. Candidates should know as soon as possible exactly what is being asked. The "better" stem not only states the problem clearly, it also relates each option to the intent of the item.

Writing the options

Make one answer the correct one

Multiple choice items ask candidates to choose a single correct answer from the options provided. Presented with more than one plausible answer, the candidate faces a dilemma—deciding which is the proper answer. Candidates should not have to be mind-readers to figure out the intent of a question. That is the item writer's responsibility.

Vary the correct answer's position

Place correct answers randomly. Do not feel like you have to use B or C every time. Correct answers should appear in each position roughly the same number of times, but their placement should not follow a discernible pattern.

Do not give unintended clues

Make sure that the content in the stem does not clue the correct answer. Avoid synonyms or paraphrases among options. Candidates who recognize them will realize that they are the same answer but cannot both be the correct choice.

Avoid sending signals that might help candidates select the correct answer or eliminate an incorrect alternative. Most extraneous clues in multiple choice items are found in the wording. Two key sources are the "specific determiner" and the "implausible option."

Using specific determiners like "always," "never," "all," and "none" can tip off answers because candidates know that few things in life "always" or "never" happen.

Look for the grammatical clues in the two examples below:

A lateral malleolus is associated with an:

A. knee
B. shoulder
C. ankle
D. hip

An electrical transformer can be used:

A. storing electricity
B. to increase the voltage of alternating current
C. it converts electrical energy into mechanical energy
D. alternating current is changed to direct current

In the first, the common mistake of using the article "a" or "an" at the end of the stem is an important indicator of the correct answer. If a candidate already knows that the correct answer to the item is either "ankle" or "hip," the term "an" before the blank indicates that the next word must begin with a vowel, so the candidate will correctly guess "ankle." Eliminate this problem by placing the article in the options. (See example below.)

A lateral malleolus is associated with:

A. a knee
B. a shoulder
C. an ankle
D. a hip

In the second example, only answer B grammatically fits the stem. Regardless of whether candidates know anything about electrical transformers, this clue will lead them to the answer. Be sure that all options match their stems in terms of logic and grammar.

Another common—but perhaps less obvious—mistake is presenting options that are inappropriate or implausible. Candidates can dismiss such distractors immediately and increase their chances of choosing the correct answer.

Which of the following best describes an electron?

A. negative particle
B. neutral particle
C. positive particle
D. voting machine

Answer D, while clever, is so obviously wrong that no candidate who reads the item carefully will select it. The more plausible choices a candidate has, the less likely that they can simply guess the correct answer. Item writers can usually think of two good distractors for a stem, but have difficulty coming up with a third.

Do not use "all of the above" and "none of the above"

Using "all of the above" as an option lets a candidate answer an item based on partial information. They can tell that "all of the above" is the correct choice simply by knowing that two of the options are correct. In turn, they can tell that it is wrong by recognizing that at least one of the options is incorrect. Once a candidate has determined that "all of…" and "none of…" are not the correct choices, their chances of guessing correctly have doubled.

Using "none of the above" as a correct answer does nothing more than measure the ability to detect incorrect answers. The candidate does not demonstrate knowledge of what is correct.

Make structure parallel

Options for any one item should all begin with the same part of speech and be approximately the same length. A correct answer that is noticeably longer or shorter than the distractors draws immediate attention to itself. Longer options are frequently correct; it is their additional detail that makes them correct. Avoid items with a correct answer that is detailed and distractors that are vague or incomplete.

Arrange numerical options in order

For items that require a numerical response, present the options in ascending order. This is an exception to the randomization of the options rule described previously.

OUT OF ORDER: What is 100 divided by 25?

A. 5
B. 2
C. 75
D. 4

BETTER: What is 100 divided by 25?

A. 2
B. 4
C. 5
D. 75

Be careful with opposites

In fields like biology, physics, and health care in general, it seems natural to write items using distractors that are opposites, because physical events have effects that can occur in one direction or another. For example, a question might ask what happens to contrast as kVp increases. Contrast will do one of two things: increase or decrease.

How do we deal with such items? Consider the example below:

What should be changed to increase the depth of penetration of an ultrasound beam?

A. decrease frequency*
B. increase frequency
C. increase the velocity
D. decrease the amplitude

Options A and B are related to each other as paired opposites. Meanwhile, options C and D are unrelated. Savvy test takers may assume that if two of the options form a pair, one of them is likely the correct answer. In this case, the testwise candidate will immediately eliminate options C and D. Even if that candidate knows nothing, they suddenly have a 50% chance of getting it right by guessing.

Instead, write options for this type of item in one of the two ways shown below.

Form two pairs of opposites:

A. decrease frequency*
B. increase frequency
C. increase velocity
D. decrease velocity

Or, avoid opposites altogether:

A. decrease frequency*
B. increase intensity
C. increase velocity
D. decrease amplitude

This requires candidates to first recognize that frequency, not velocity, controls penetration. Next, they have to know that depth of penetration is increased by decreasing the frequency.

Here is one more example. Although the first set of options might be acceptable, some candidates will quickly rule out option B because it is different. Meanwhile, others may choose option B because it is different.

For a PA oblique projection of the optic foramen, the central ray should be directed:

A. parallel to the interpupillary line
B. perpendicular to the interpupillary line
C. parallel to the acanthomeatal line*
D. parallel to the glabellomeatal line

The set of options below is better. They are parallel in structure (two pairs of opposites) and provide less clueing. Candidates must discern between two lines (interpupillary vs. acanthomeatal) and two planes (parallel vs. perpendicular).

A. parallel to the interpupillary line
B. perpendicular to the interpupillary line
C. parallel to the acanthomeatal line*
D. perpendicular ot the acanthomeatal line

Section Review

As stated at the beginning, these are only guidelines. Follow them when they are logical; break or bend them if doing so will improve an item's effectiveness. The following checklist may be helpful for evaluating MCQs that you or others have written.

Item Review Checklist

- What bit of knowledge are you trying to assess? Does the stem present this as a single, clearly formulated problem?
- Is the stem stated in simple, clear language?
- Is the stem worded so there is no repetition of material in the options?
- Is the stem stated in positive form whenever possible?
- Are negatively worded stems capitalized properly? (NOT, EXCEPT)
- Is the item written in a manner that is unbiased in terms of gender, culture, race, etc.?
- Is the intended answer correct or clearly best, and is there only one correct answer?
- Are all the options grammatically consistent with the stem?
- Are the options free from verbal clues to the correct answer?
- Are the distractors plausible to the uninformed?
- Is the correct answer about as long as one or more of the distractors?
- Have "all of the above" and "none of the above" options been avoided?
- Is the position of the correct answer varied so there is no detectable pattern?
- Are options in logical order when appropriate or in random order when called for?
- Are the options parallel in structure and form when applicable?
- In general, does the item's format and grammar facilitate efficient and easy test taking?

Chapter 4 – Strategies for Item Production

Chapters two and three described several MCQ formats and discussed editorial guidelines for stems and options. That was the easy part. The hard part is sitting down to put your ideas on paper. This chapter describes a five-step process for turning ideas into test items. It is intended to help item writers organize their thoughts and overcome writer's block.

Five-step process

For most writers, the task begins by thinking of a topic and does not end until after editing what they have written.

We have divided the production process into five steps because it is convenient, seems logical, and bears some similarity to what some of our better item writers have done over the years.

The five steps we suggest are:

1. Identify a topic and supporting information
2. Determine the candidate's cognitive task
3. Formulate the stem and correct answer
4. Write the distractors
5. Review the item

Although each step can be described as a separate activity in theory, in practice they meld together to form a more-or-less continuous process. It is not always necessary to perform each step; sometimes they just occur automatically. We still find it helpful to break the process down into discrete steps that can be analyzed and discussed, which has the bonus value of sometimes helping overcome writer's block.

Identify a topic and supporting information

ARRT's exams are built using Content Outlines that consist of a topic outline and a Task Inventory. Both pieces are essential for item writing, as they define the scope of topics that the items can address.

An example of this is the following task from the Radiography Task Inventory:

> *Modify exposure factors for circumstances such as involuntary motion, casts and splints, pathological conditions, contrast agent or patient's inability to cooperate.*

Although the physical task of modifying exposure factors is fairly simple, doing it correctly requires extensive knowledge of numerous topics including attenuation, the relationship between kVp and penetration, impact of pathological conditions on tissue density, and so on. You recall from your own experience that this is indeed an important task and that, as an entry-level technologist, your knowledge of related subjects was critical to performing this task effectively. So, you decide to write an item on attenuation.

Attenuation is a basic subject on which it may be fairly easy to write a test item without any references. However, consulting multiple references or other sources can be helpful in several ways:

- Test specifications often lack the detail needed for item development. A good textbook or article will fill in any gaps.
- References can verify that you are using precise terminology (e.g., is the correct term technical factors or exposure factors? Compton scatter or scattering?).
- Looking into multiple references will likely lead you to ideas for several test items instead of just one or two.
- ARRT requires that item writers provide references for all submitted items.

We suggest that item writers refer to textbooks, major reports (e.g., NCRP, NRC, OSHA), or curriculum guides. Major textbooks are the preferred source. Avoid single-source or internet-based references, as these can often be incorrect. Stick with peer-reviewed resources.

In the pages that follow, we refer to a textbook chapter on attenuation. Text like this from a well-organized book can serve as the basis for numerous test items.

> *Attenuation is the reduction in the number of x-ray photons remaining in the beam after the beam passes through a substance. It is the result of the x-ray beam interacting with matter and losing energy, or photons, through these interactions. There are five mechanisms by which x rays interact with matter: coherent scattering, Compton effect, photoelectric effect, pair production, and photodisintegration. Of the five types of interactions, two are important for the production of radiographs: the Compton effect and photoelectric absorption.*
>
> *The Compton effect, also called Compton scatter, occurs when an x-ray photon interacts with an outer-shell electron in body tissue, which causes the photon to lose energy and change direction, or scatter. The outer-shell electron is ejected from the atom. The ejected electron is called a secondary electron or Compton electron. Some of the scattered radiation may reach the image receptor. Because it is of low energy and strikes the image receptor from different directions, it decreases and creates a uniform darkness on the image, called fog. Although Compton scatter is typically low energy, it is still sufficient to require that x-ray examining rooms be shielded.*
>
> *Photoelectric absorption results when an x-ray photon interacts with an inner-shell electron. The photon is not scattered but is absorbed by the substance, resulting in a reduction in the number of photons that pass through the substance. The inner-shell electron that is released from the atom is called a photoelectron.*
>
> *One factor that determines the amount of attenuation is the type of irradiated substance. Thicker body tissue results in greater attenuation, as does more dense body tissue. When body size is doubled, the chance of x-ray interaction is doubled because twice as many electrons are available for interaction, and more photons will be absorbed. Attenuation is also affected by the atomic number of the substance because substances with high atomic numbers have more electrons*

available for x-ray interaction. Three cm of bone will attenuate more of the x-ray beam than 2 cm of bone, and 3 cm of bone will attenuate more than 3 cm of muscle.

Determine the candidate's cognitive task

After identifying a topic, your next step is to consider what you expect the candidate to do with it. Given that written exams are limited to testing for cognitive knowledge and skill, the candidate's task is a mental, not physical, activity. So, this step is about deciding whether the candidate should have to remember some fact, apply a formula, interpret patient data, evaluate a radiograph, and so on.

Begin by clarifying the topic. In the example above, attenuation is the general topic, but it comprises several specific pieces of knowledge. Most test items are about these specific units of knowledge, which can include facts, concepts, or principles.

Facts are things that are known or proved to be true. For example:

- attenuation is the reduction in the number of x-ray photons remaining in the beam after it passes through a substance
- the ejected electron is called a secondary electron

Concepts are characterized by their defining attributes. For example, the concept of a bird is defined by attributes such as feathers, two legs, wings, egg laying, and so on. The concept of radiographic quality is defined by attributes such as brightness, recorded detail, and so on.

Principles involve cause–effect relationships and often take the form of "if … then" statements. Radiologic technology is driven by principle. The inverse-square law is one very well-known principle; the relationship between kVp and penetration is another. Among the principles in the text box is: "If a substance has a high atomic number, then more electrons are available for x-ray photons to interact with, and more photons will be absorbed."

Once you have identified the facts, concepts, and principles, it is relatively easy to specify the candidate's task. The item below presents several task statements related to attenuation. Each identifies—most at the beginning—the type of cognitive skill we expect to be demonstrated.

We could easily develop more. The important thing to recognize is that it is not necessary to actually write down all of these tasks when creating test items. It is important to locate a good reference, read the relevant sections, and give some thought to the cognitive behaviors you seek to evaluate. See a list of sample tasks below.

The candidate will:

- Recall that fog is defined as unwanted exposure that is uniformly distributed over the image
- List the five types of interactions between x rays and matter
- Recall that the photoelectric effect and Compton effect have important implications for image production
- Recognize that coherent scattering typically has a negligible effect on radiographic quality
- Differentiate, given a line drawing of an atom, a photoelectron from a Compton electron

- Recognize why substances with higher atomic numbers absorb more photons
- Recognize the definition of a secondary electron
- Explain the event that occurs when an x-ray photon interacts with an outer-shell electron
- Given a simple line drawing of an atom (neutrons, protons, electrons), indicate the electron shell at which the photoelectric effect is likely to occur
- Identify tissue density as one of the factors that affect the amount of x-ray beam that is attenuated
- Given a list of common substances (e.g., bone, muscle, water, barium), estimate which has the greatest and least amounts of absorption
- Explain how scatter results in fog

Here are a few cognitive behaviors to use in your own work: analyze, choose, compare, comprehend, conclude, define, detect, differentiate, distinguish, estimate, explain, identify, indicate, list, match, plan, predict, recall, recognize, restate, select, state, and understand.

Formulate the stem and correct answer

After you have considered the candidate's task, it is time to do some writing. The stem and correct answer are pretty straightforward. As we shall later see, writing distractors is the hard part!

Candidates must be given a clearly stated and complete problem to solve. Occasionally, it is even OK to include information that might lead the candidate to an incorrect answer. Although we do not want to trick them, it is perfectly acceptable to determine whether they can differentiate relevant from irrelevant information.

It is almost always best to phrase the stem as a direct question, which helps ensure that it poses a focused problem. After writing the stem and options, if it is apparent that the stem would read better as an incomplete statement, then you may want to go back and revise the stem. The best item writers start with a strategy for focusing the problem. Chapter three offered several guidelines related to writing the stem; follow those and you will be in good shape.

Write the distractors

The primary difficulty with writing distractors is that most of our thinking is oriented to the correct answer. When we identify information to support a topic, we typically focus on correct—not incorrect or misleading—information.

Here are a few tips:

- Try to anticipate incorrect responses from uninformed and misinformed candidates. The uninformed just do not know, and any distractor works for them. The misinformed know only a little about a topic, or they are confused by a misconception. This is the person who mistakes quality for quantity or forgets to invert when thinking about the inverse square law. Try to put yourself in their shoes. What are some common misconceptions about this topic? What parts are most difficult to master or easiest to forget?
- Develop distractors from irrelevant attributes—those features that define a related concept. For example, an irrelevant attribute of the photoelectric effect is its interaction with an outer-shell electron (remember that outer-shell electrons are an attribute of the Compton

effect). Therefore, an item about photoelectric effect might have outer-shell electron as a distractor.

- If a test item calls for an example of a concept, you can transform bad examples into distractors. Consider an item that asks for examples of the five types of interactions between x-ray photons and matter: It might use distractors like fusion, induction, and differential absorption.
- It is usually pretty easy to write distractors for principles, because they deal with relationships, usually "if…then" relationships. An item that asks about the effect of mAs on patient exposure could have options such as increases, decreases, or stays the same. These options all deal with the direction of the relationship. Alternatively, options can be about the strength of the relationship (e.g., "Doubling X will have what effect on Y? — halve, double, quadruple"). Options may also pertain to the shape of the relationship (proportional, geometric, logarithmic, inverse, and so on). For certain types of questions, it is impossible to come up with four reasonable options. In some instances, it is OK to have three, such as increases, decreases, and remains the same.
- Another feature of principles is that they are often expressed mathematically. Recall that the inverse-square law states that the intensity of radiation at a given distance from the source is inversely proportional to the square of the distance, or, $I_2 = I_1 \times D_1^2 / D_2^2$.

Now consider the item below:

> An exposure of 200 mR is obtained at a distance of 20 inches. What will the exposure be if the distance is increased to 40 inches?
>
> A. 16 mR
> B. 50 mR*
> C. 400 mR
> D. 800 mR

The correct answer is: $200 \times 202 / 402 = 50$ mR. All of the options should come from misapplications of the principle, such as forgetting to square one or both values, taking the square root, dividing instead of multiplying, and multiplying instead of dividing. For this example:

- distractor A was obtained by: $40^2 \times 20^2 / 200^2 = 16$
- distractor C was obtained by: $200 \times 40 / 20 = 400$
- distractor D was obtained by: $200 \times 40^2 / 20^2 = 800$

For some math items, you can create plausible distractors by moving the decimal, using parentheses incorrectly, or varying the number of zeros. Consider these types of distractors if the item involves converting from one unit of measure to another (e.g., inches to centimeters), when dealing with the metric system, or for items that require scientific notation.

Remember: for distractors to appear plausible, they must be thoughtfully crafted. Do not just make up wrong answers; derive them by attempting to mimic common misconceptions and mistakes. Several sample test questions that illustrate these points appear in the following pages.

Review the Item

Just as important reports or letters require careful proofing and editing, so do test items. The benefit is twofold: first, it improves the item; second, the revision process can generate even more items on the same topic. Guide your item review using the checklist presented at the end of chapter three.

Putting It All Together

Remember the paragraph on attenuation and the following candidate task statements? Here is where we convert them into test items. Several items are presented below, along with comments.

> Which of the following are considered to be the two most important types of interactions for radiography?
>
> A. coherent scattering and photodisintegration
> B. pair production and photodisintegration
> C. Compton effect and pair production
> D. Compton effect and photoelectric effect*

This item evaluates the candidate's ability to recognize some fundamental facts about types of interactions relevant to radiography. Although pretty basic, it is a good solid item. Notice that the distractors all correspond to related concepts taken from other task statements.

> Which of the following types of interactions between x rays and human tissue is associated with fog on an exposed radiograph?
>
> A. coherent scattering
> B. Compton effect*
> C. pair production
> D. photodisintegration

This one goes beyond basic scientific facts by requiring candidates to understand the impact of certain types of interactions on an actual radiograph. This is not necessarily a better item, but its relevance to practice is more obvious.

> Compared to substances with lower atomic numbers, those with higher numbers:
>
> A. absorb more energy from the x-ray beam*
> B. absorb less energy from the x-ray beam
> C. are associated with thicker body tissue
> D. are associated with thinner body tissue

Here we get away from facts and into principles, with one of those important "if…. then" relationships. Note two things about the options: first, they form pairs of opposites (generally a good approach); second, the concepts in each of the options are based on ideas taken from the list of task statements presented earlier.

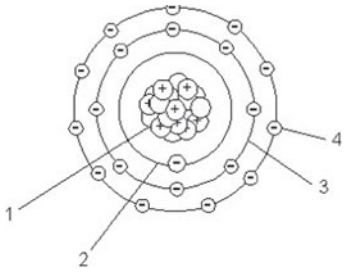
As the density of a material is doubled, the probability of an x-ray interaction:

A. is reduced by half
B. remains the same
C. is doubled*
D. is quadrupled

Note the distractors on this item: option A is plausible to a misinformed or confused candidate because it is the inverse of the correct answer; option D might be an attractive guess for an uninformed candidate who has heard of the inverse-square law. Option B probably is not very effective; it may be better as a three option MCQ (i.e., increases, decreases, remains the same).

What number in the figure corresponds to the K-shell?

A. 1
B. 2*
C. 3
D. 4



The item refers to a common drawing depicting interactions between x rays and matter. Simple but effective, it requires the candidate to identify a correct label for a part of the drawing. In the health sciences, items like this are highly effective (anatomy, positioning, drawings of equipment, and so on).

What number in the figure indicates the likely location for photoelectric absorption?

A. 1
B. 2*
C. 3
D. 4

Similar to the previous item, this item shows how drawings can do more than identify parts: candidates must demonstrate a deeper level of understanding of a process. You can also write items about how parts interact with other parts, what happens when they malfunction, and so on (see Chapter 2).

Items with Images

Original drawings or tables that you create work the best because then no additional permissions are needed to publish your original work.

ARRT does not accept images or illustrations from sources such as books or the internet due to copyright infringement. ARRT prefers images of patient anatomy from the clinical setting over original anatomical illustrations.

If the image that you select to accompany your item is an original image from your institution, please make sure that you check with the institution about their policies for copying images. Make certain that all patient identifying information has been removed.

Please submit two copies of the image—one with no markings and one with the appropriate marking (for example, “The arrow points to what blood vessel?”).

If you are using an image from the ARRT ImageBank, please refer to the ImageBank Item Writer Instructions. This document provides further details on how to communicate which image you have selected to use from the bank.

Section Review

Before leaving this chapter, let us restate the five steps of item production:

1. Identify a topic and supporting information
2. Determine the candidate’s cognitive task
3. Formulate the stem and correct answer
4. Write the distractors
5. Review the item

We would also like to re-emphasize that it is really not necessary to follow this process in lock-step fashion. If you skip one, that is fine. Merge steps together—that is OK, too. Maybe two big steps will work: 1 and 2, then 3 through 5. Make them work for you.

The important point of the exercise is this: obtain supporting information and think clearly about what you expect the candidate to be able to do with that information.

Chapter 5 – Critical Thinking and Clinical Problem-Solving Skills

Chapter four identified basic strategies for writing test items. Now we put them to work. We begin by discussing levels of cognitive complexity. Then we demonstrate strategies for producing items that assess those higher-order thinking skills. The final part of the chapter discusses test items that assess clinical decision-making skills—the types of skills that technologists exercise in their day-to-day work.

Levels of Cognitive Complexity

Many theories describe the cognitive processes used in clinical and didactic settings with terms like prioritizing, inferring, analyzing, problem solving, and evaluating. Phrases like higher-order thinking skills, critical thinking, and clinical decision making have enjoyed popularity in recent years.

Bloom's Taxonomy is the most widely recognized framework for describing levels of cognitive complexity. It identifies six levels of cognitive skills: knowledge, comprehension, application of knowledge, analysis, synthesis, and evaluation. This framework has been very useful, and all six levels come into play when writing test items. But we believe a simpler framework, consisting of just three levels of cognitive complexity, works just as well:

Recall/Recognition: Test items at this level require candidates to recall or recognize previously learned facts, concepts, and principles. Examples of a cognitive skill at this level: listing the bones of the foot on an anatomical image; being able to restate the inverse square law verbatim.

Application: Test items of this nature require candidates to apply previously learned information to a practice-related problem. Calculating new exposure factors based on application of the inverse-square law is an example of this type of test item.

Problem Solving: Items at this level involve analyzing situations, evaluating information, and determining solutions to problems. Candidates are required to use information they already know, evaluate information that is supplied by the test item, then integrate the two to solve the problem posted by the test item. Problem solving usually requires critical thinking.

Two Important Caveats

First, these three levels are not carved in stone, nor are they any better than the six levels proposed in Bloom's taxonomy. Whether there are two, three, or eight levels probably does not matter. What is important is for item writers to think about the cognitive demands of the test questions they write.

Second, a test item's cognitive complexity depends on more than just the topic of the item. It also depends on the number of mental processes asked of the candidate. How many pieces of information the candidate needs to recall and the number of mental steps they need to take with the recalled knowledge from their memory to answer the question are crucial factors to consider. The attractiveness of distractors is another important factor. Some studies have shown that test items classified as analysis or problem solving are not any more difficult than those classified as recall or comprehension, and additional facets of item complexity may be the reason.

It is helpful to understand the complexity and difficulty of the tasks you intend to set for candidates. Test items vary in terms of the cognitive demands they place on candidates. The rest of this chapter contains a few strategies to help you write test items that will require candidates to put on their thinking caps.

Assessing for a Deeper Level of Understanding

Three strategies that can turn basic recognition items into items that assess critical thinking are asking: "why," "what if," and "how."

An effective way to assess knowledge at a deeper level of understanding is to require candidates to explain the rationale underlying some concept or principle. A candidate may know that bone attenuates the x-ray beam more than muscle does, but do they really know why? Alternative questions could ask the candidate to explain why some tissues absorb more than others, or to describe the conditions that result in higher levels of scattered radiation.

> Which of the following is likely to decrease bone mineral density in a premenopausal patient?
>
> A. cigarette smoking*
> B. membership in Weight Watchers
> C. nulliparity
> D. use of birth control pills
>
> Why does cigarette smoking result in decreased bone density in a premenopausal patient?
>
> A. the decrease in oxygen supply associated with smoking decreases the oxygen available for bone formation
> B. smoking overstimulates the production of osteoblasts
> C. smoking suppresses overall metabolism thereby decreasing the regularity of the bone formation cycle.
> D. smoking chemically alters estrogen so that it no longer contributes to bone formation*

There is an art to asking "why" within the confines of the MCQ format. Consider the two items above. The first simply requires candidates to recognize that smoking is a risk factor for osteoporosis. The second one requires some understanding of why smoking is a risk factor.

The second of these is a cognitively complex and difficult item. However, it illustrates a couple of potential limitations to asking why. First, such questions often require lengthy options, because each must offer a plausible explanation, and explanations usually require many words. Long options are acceptable; it just takes extra care to assure that they are not too wordy.

Second, asking "why" can make very hard questions out of easy subject matter. Is why important in this situation? The Examination Committee felt that knowledge of why for this particular topic was not essential to effective job performance and thus not appropriate for an ARRT exam.

Sometimes the correct answer depends on certain conditions. Drawing on these conditions can open the door to additional test items. The first item below is a simple one about the attenuating effects of different types of tissue. You can make this topic more complex by asking about the

effects of different types of bone or of various pathologies. For example, what if the patient has received radiation therapy, or is postmenopausal? How would these factors influence density and attenuation? The latter two questions require a deeper level of understanding than the first.

Which of the following substances attenuates an x-ray beam the greatest amount?

A. muscle
B. fat
C. air
D. bone*

Osteoporotic bone affects the interactions of x-ray with bone because it:

A. attenuates more photons
B. attenuates fewer photons*
C. produces more scattered radiation
D. decreases contrast

Compared to normal breast tissue, the radiographic density of an irradiated breast is:

A. radiolucent
B. more dense
C. less dense*
D. of equal density

You can determine if candidates know how some piece of information applies to clinical practice. A related strategy is the so what line of questioning, which requires candidates to understand how certain things impact practice. The items below assess the ability to adapt and apply knowledge to nonroutine situations.

How might the technologist modify the radiographic technique for an AP hip for a patient diagnosed with severe osteoporosis?

A. increase exposure factors
B. decrease exposure factors*
C. no change to exposure factors

What changes in exposure factors may be required for elderly patients scheduled for a mammogram?

A. increase kVp
B. decrease kVp*
C. increase focal spot
D. decrease focal spot

Assessing Clinical Skills

So far, this chapter has addressed primarily didactic knowledge. Now, we turn to the assessment of clinical skills. Although the strategies just presented (asking “why,” “how,” and “what if”) also apply to clinical skills, a few additional tricks can be helpful when writing items that require candidates to apply their knowledge to practice-related problems.

Let us clarify what we mean by clinical skills. Listed below are a few examples of clinical activities that occur in the practice setting.

- Transport a patient with a fractured hip
- Set up equipment for a PA chest radiograph for a pediatric patient
- Explain breathing instructions to patient for a PA chest radiograph
- Perform a QC test for a collimator light

Each of these activities involves patients, equipment, or both. Each also requires some sort of psychomotor skill and may even involve interpersonal or communication skills. Most importantly, none of these activities can be directly assessed with MCQs. Not even the best test item can test a technologist's ability to transport a patient or set up equipment. Truly assessing such skills requires observing a technologist's interaction with an actual patient in a clinical setting with real equipment.

The alternative is to develop clinically relevant test items that test the knowledge that is required to safely perform the tasks from the ARRT Task Inventory for the appropriate discipline. Key to writing good practice-based items is the fact that all clinical activities require some type of knowledge. In other words, you can assess clinical skills by assessing the knowledge and cognitive skills that underlie the procedures.

Steps of a Procedure

MCQs can determine whether a candidate can identify the appropriate steps and place those steps in proper sequence. Alternatively, you can give candidates the steps and ask them to name the procedure or explain its purpose. The item below requires candidates to know that anesthetic is given prior to doing a bronchogram. The next two items pertain to QC tests: one for a compression device on a mammography unit, and the other for a collimator light on a radiographic unit.

> When performing an arthrogram, what is usually done prior to inserting the needle?
>
> A. a local anesthetic such as lidocaine is administered to the site*
> B. the patient is instructed to exercise the joint
> C. a general anesthetic is administered so that the patient remains unconscious
> D. lab tests are performed to determine the patients BUN

To have correctly answered the following item, the candidate must have known not only that the towel needed to be placed on the cassette before the scale, but also what equipment was used (e.g., towels are, phantoms are not). The 1999 ACR Mammography Quality Control Manual clearly described the steps of this procedure.

> What is the first thing to do when using a bathroom scale to perform a compression test on a mammographic unit.
>
> A. activate and deactivate the compression device 3 times to warm it up
> B. place the scale between the cassette and the top compression paddle
> C. place a towel on the cassette*
> D. place a phantom on the cassette

Concepts and Principles Underlying a Procedure

Although test items about the steps of a procedure are useful, they often require little more than recall of facts. It is possible to move beyond recall, with items that assess:

- How a certain step is performed
- Why a certain step is performed; why it is needed
- Why one step occurs before or after another
- Types of equipment and instrumentation required; knowledge of that equipment (e.g., how it works)
- Anatomy, physiology, or pathology involved in the procedure
- Critical things to be careful of when performing a step
- What happens if a certain step is omitted, performed incorrectly, or performed with inadequate instrumentation
- Indications or contraindications for a procedure

The items below assess some of these cognitive skills. The first two pertain to an ERCP, while the remaining two are based on the mammography compression test. Most require the candidate to demonstrate fairly detailed knowledge about the steps of a procedure by asking "why," "what if," or "how."

When performing an ERCP, contrast is used to enhance the biliary ducts. To introduce the contrast, it is necessary to first locate what anatomical structure with the endoscope?

A. common bile duct
B. ampulla of Vater
C. islets of Langerhans
D. sphincter of Oddi*

When performing an ERCP, why is the larynx anesthetized prior to inserting the endoscope?

A. to prevent esophageal reflux when contrast is introduced
B. to minimize superimposition of the thyroid cartilage
C. to minimize interference from the tongue
D. to prevent gagging when the endoscope is introduced*

Why is it necessary to place a towel on the cassette holder before performing a compression test on a mammographic unit using a bathroom-type scale?

A. to prevent damage to the cassette holder*
B. to protect the scale
C. to simulate the compressibility of breast tissue
D. to calibrate the unit before performing the compression test

A mammography unit should be subjected to a compression test whenever inadequate compression is suspected, and every:

A. day
B. week
C. month
D. 6 months*

Clinical Data or Procedure Outcomes

Procedures result in a product that is either an end in itself or used as input to some other procedure. Here are a few of the related cognitive skills standard MCQs can assess.

- Interpreting the results of, or output from, a procedure
- Evaluating results or output for quality (e.g., radiographic contrast, distortion, etc.)
- Recognizing limitations of the process or the instrumentation involved
- Knowing what and how to document

The item below illustrates this idea by picking up on the mammography QC theme. It requires candidates to evaluate the outcome of the QC test and justify a course of action. MQSA and ACR require it, so they need to know it.

A compression test on a mammographic unit consistently gives readings of 21, 22, and 23 pounds on three testings obtained within a few minutes. What should be done?

A. record the average value, and repeat the test at the next scheduled interval because the values are within acceptable limits
B. record the high value, and repeat view the test at the next scheduled interval because the values are within acceptable limits
C. contact a service engineer or physicist because the values are not within acceptable limits*
D. recognize that the measurements are inconsistent, and repeat the test on the next working day to confirm the results

For another example, an item might require evaluating radiographic quality by presenting a mammogram and asking the candidate to decide what view to do next.

Unexpected Circumstances: What to do Next

Here is a twist on a strategy that was briefly mentioned earlier. Sometimes, for various reasons, things go wrong. It could be that the patient does something unexpected, has variant anatomy, or is limited by injury or pathology. Equipment problems may also require a technologist to respond quickly.

The item below asks the candidates what to do next. Keep in mind that items like this often require common sense or sound clinical judgment, and it can be challenging to write distractors that are plausible but incorrect. Another challenge is that what is viewed as appropriate at one facility might not be practiced industry-wide.

A patient for a routine chest radiograph exhibits seizure-type behavior, and then falls to the floor. They appear to be unconscious but breathing. What should be done first?

A. check for head injuries due to the fall
B. obtain radiographs for any regions where injury is suspected
C. attempt to arouse the patient
D. call or send for a physician as quickly as possible*

Content Mapping

One tactic for identifying a number of possible item topics is content mapping. Begin with a concept or task that a successful candidate should understand in order to function well in the role of a new technologist. Think about other pieces of knowledge and mental skills that are connected to the first concept or task. List the connected concepts or tasks by placing them in order from the most complex or difficult to the least.

Some concepts or tasks lend themselves to having multiple choice items written about them more easily than others. By listing a number of related concepts, you should identify at least one that can become a good item. Placing the concepts and tasks in order of complexity or difficulty should increase your understanding of the content, and how well candidates may respond to the items. Certain item topics and tasks tend to lead to items that are very easy, or very difficult. By listing a number of connected tasks, it may be easier to create an item that is useful. For instance, in topics that tend to be easier, a more complex task could produce a useful item.

Section Review

This chapter presented a simplified cognitive taxonomy consisting of three levels of processing: recall/recognition, application, and problem solving. Although it seems that most items are written at the recall level, it is not difficult to write items that involve application or problem solving. Strategies for writing items at the higher two levels include asking "why," "what if," and "how."

We also discussed the nature of clinical problem solving and how MCQs can be written to get at clinical skills. Although it is not feasible to write items that directly evaluate a candidate's ability to actually carry out a procedure, it is possible to assess cognitive processes. Examples include:

- knowledge of the steps of a procedure
- principles underlying each step
- ability to evaluate the data, results, or other outcomes from a procedure
- skill at managing unexpected circumstances

Applying the techniques covered here, many item writers find they can make their multiple choice items more challenging and more relevant to clinical practice.

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Appendix A – Formats ARRT Does NOT Use

True/False

Description: With a true-false item, a statement is presented, and the examinee indicates whether the statement is either true or false. There are only two possible responses for each item.

Why ARRT does not use this item type: Since the examinee has only two options, an examinee with no knowledge of the subject matter has a 50-50 chance of getting the item correct. Often, the stem of the true-false item must be written so specifically that the examinee is given clues as to the correct answer. In those cases, the examinee will have more than a 50-50 chance of getting the item correct with minimal or no knowledge of the subject matter.

Matching

Description: A matching item format is two columns of terms or phrases and the examinee is asked to find the relationship between a term/phrase in one column and a term/phrase in the other column. They test the examinee's ability to find the relationship between two sets of stimuli.

Why ARRT does not use this item type: This type of item is best suited for testing recall and is not very effective for testing higher order knowledge.

Fill-in-the-Blank

Description: The candidate's task is to identify the word or phrase that goes in the blank. Most experts agree that the sentence-completion format often leads to items that are not very clear.

Why ARRT does not use this item type: Item writers occasionally confuse the incomplete statement and sentence completion (fill-in-the-blank) formats.

"None of the Above" and "All of the Above"

Description: One of the possible multiple choice answers allows a candidate to endorse or reject all other options

Why ARRT does not use this item type: Anything they may accomplish can be better achieved with the multi-select format.

Appendix B – Item Review and Critique

The amount of radiation necessary to produce a noticeable skin reaction is called an:

A. depth dose
B. erythema dose*
C. filtered radiation dose
D. irradiation dose

Problem: since the stem ends in an, the correct answer must begin with a vowel.

Solution: some might change the stem to *a(an)*, but we suggest adding *a* or *an* to each option.

What is the normal kVp range used in mammography?

A. 20-25 kVp
B. 30-35 kVp*
C. 25-40 kVp
D. 35-50 kVp

Problem: the options overlap; thus C is partially correct

Solution: ranges should not overlap. Also, try to make them the same width (e.g., 30-35, 40-45)

What is the primary reason for spreading a treatment dose over a number of applications rather than giving it all at once?

A. normal cells repair themselves more quickly than cancer cells*
B. it makes less efficient use of staff time since multiple visits are required
C. evens out the workload
D. multiple exposures increase the probability of negative side effects

Problem: Options B and D are not plausible. The stem asks for an advantage, but these options are obviously disadvantages. Even option C is a bit silly. Workload should never be the reason for choosing a method of treatment. In sum, anyone with common sense would choose A.

Solution: The three distractors should be rewritten.

Artifacts that occur in ultrasound imaging include all of the following EXCEPT:

A. scanning the wrong area*
B. demonstrating posterior enhancement
C. producing acoustic shadowing
D. slice thickness

Problem 1: The stem is a negative; it is OK but not optimal. The real flaw is in the options. The stem tells us to look for an artifact that does not occur, so option A is the logical choice because it is not an artifact.

Solution 1: Clarify the intent of the stem and rewrite option A so that it is an artifact, but one that does not occur in ultrasound.

Problem 2: Options A–C start with a verb: scanning, demonstrating, producing. Option D does not.

Solution 2: Reword Option D so it follows the same structure as the other options.

Three of these sentences about the prostate are correct. Which one is incorrect?

A. the prostate capsule is indistinct from the surrounding fascial tissue
B. the normal average size prostate is 4 x 3 x 3.8 cm
C. the seminal vesicles are paired structures
D. there is only one vas deferens and it originates from the epididymis*

Problem: This is another example of an unfocused stem and wandering options. One option pertains to size, while each of the others deal with other anatomical features.

Solution: Pick an option and build the stem and new options around it. For example: “What is the approximate size of the prostate?” with all options pertaining to size, or “Where do the vas deferens originate?” with all options listing alternative origins.

An 18-year-old patient with a leg injury from an automobile accident is referred to the radiology department by the ER physician. The written request specifies radiographs to determine if the kneecap is fractured. What is the medical term for kneecap?

A. mandible
B. femur
C. patella*
D. flabella

Problem: Although all that information in the stem sounds clinically relevant, it makes the stem distracting and hard to read. This might be OK for a reading test, but not for a certification and registration exam.

Solution: Drop everything from the stem except the last sentence.

What bone is juxtaposed to the radius?

A. ulna*
B. humerus
C. scaphoid
D. tibia

Problem: Why use a term like *juxtaposed*? This is another item for the reading comprehension test.

Solution: Replace *juxtaposed* with *adjacent to*, *next to*, or *parallel to*. Or use medically relevant language like *medial, lateral, proximal*, or *distal*.

All of the following sound be avoided by patients receiving head and neck radiation EXCEPT:

A. alcohol
B. high caloric foods
C. spicy or acidic foods
D. fry or coarse foods

Problem: Is it necessary to state this item in the negative? It even has two negatives (avoided… except). Options C and D each have two elements connected by the word or, which further complicates things.

Solution: Rewrite the stem to: Which of the following should be recommended for a patient receiving radiation therapy to the neck? Then carefully verify that the wording of options C and D is exact.

To increase percentage depth dose, one could:

A. decrease treatment distance
B. remove the filter
C. lower tube current
D. increase treatment distance

Problem: Options A and D are paired opposites, which makes them attractive to test-wise candidates.

Solution: Revise the other options so that they form a pair: *increase filtration, decrease filtration* OR *increase treatment time, decrease treatment time.*

Which of the following is commonly given for relief of minor pain?

A. an analgesic
B. heparin
C. acetaminophen*
D. Vesprin®

Problem: Options overlap: C is a subset of A. If C is correct, then A also must be correct. The real problem is that the options are written at different levels of specificity:

- Option A is a drug class
- Options B and C are generic names
- Option D is a trade name, which ARRT discourages use of

Solution: Either stick with classes (analgesics, corticosteroids) or generic names (acetaminophen, diphenhydramine).

A technologist in your department informs you the automatic exposure control seems to be malfunctioning. You inspect the equipment and agree. What should be done next?

A. perform the necessary adjustments
B. tell the technologist to use manual exposure based on technique charts
C. notify the radiation physicist*
D. notify the department manager

Problem: Items like this are sometimes institution specific. Option C is keyed as correct, but option D might be correct for many institutions. Some facilities might take actions not listed here.

Solution: Be careful about items that get into practice activities that legitimately vary from one setting to the next. Other ways to phrase such items might be "According to the NRC," or "According to MQSA guidelines."

The radiographic appearance of the breast may be affected by:

A. age
B. hormonal status*
C. intake of ascorbic acid
D. number of previous mammograms

Problem: Here is a different type of "overlapping options" problem. In this case, age and hormonal status are highly related, so option A is potentially correct.

Solution: Options should be independent. Revise option A.

What is normal adult body temperature?

A. 99.4° F
B. 98.6° F*
C. 37.2° C
D. 37.6° C

Problem1: The options have multiple units of measurement: Fahrenheit and Celsius. This is not necessarily bad—it depends on the purpose of the item.

Solution 1: If the intent is to determine if candidates know normal body temperature, then they should be asked in the temperature units they should be expected to know. If they should know both units, then two questions might be legitimate.

However, if the purpose of the item is to determine if candidates can convert from one unit to the other, then the stem should be rewritten, and the distractors should be derived from misusing the conversion rule.

Problem 2: According to the current AMA style guide, there is a full space between temperature values and degree symbols.

Solution 2: Format the options as such: 99.4 °F

Radioactive materials may be disposed of by all of the following EXCEPT:

A. by transferring it to a licensed land disposal facility
B. decayed in storage, released into general waste if below specified radiation limits
C. they may be returned to the licensed supplier
D. encased in a lead container, released into general waste*

Problem: It is negatively worded, but that is a minor issue here. The major problem is that not all options complete the stem in a grammatically correct way. They are not parallel in structure. Option A is OK; but B, C, and D are not. Sharp candidates will wonder how an option can be correct if it does not logically complete the stem.

Solution: Either put the word by at the end of the stem and start each option with an -ing verb, or state the stem as a question like this: “Which of the following methods should NOT be used for disposal of radioactive materials?”

To increase the depth of penetration of a sound beam, a sonographer should:

A. decrease frequency*
B. increase frequency
C. increase the velocity
D. decrease amplitude

Problem: Options A and B are a pair of opposites, which means that one of them is probably correct.

Solution: Create another pair of opposites (just be sure they are not correct). Another solution is to have no pairs. For example, just change option B to *increase intensity*.

The total radioactivity of a sample is 32 mCi. After 12 days, the radioactivity of the sample is 4 mCi. It's physical half-life (in days) is:

A. 8
B. 2
C. 4*
D. 12

Problem: The options are not in logical order

Solution: Arrange options from lowest to highest. Also consider adding days to each option for ease of reading

When dealing with an asthmatic patient, the sonographer should do what?

A. place the patient in the Trendelenburg position
B. remain calm and confident*
C. continue scanning while help comes
D. prohibit the patient from taking his own medications

Problem 1: The stem is vague. Apparently, the asthmatic patient has a reaction, although the stem does not say this. Also, the options are a problem. Option B is a giveaway, and it could be the correct answer for any number of questions.

Solution 1: Revise the stem to something like: A patient experiences an asthmatic episode during a routine abdominal scan. What should the technologist do? It is tough to write distractors for "common sense" patient care items like this. Often, the incorrect answers are too obviously incorrect. Try to write on topics that can be backed up by scientific principles (e.g., normal values, body mechanics), best practice guidelines, or rules and regulations.

Problem 2: The use of a gendered pronoun in the options is unnecessary, as the patient's gender is not clinically relevant in this case.

Solution 2: Replace *his* with *their*

A patient for a GI study requires special dietary instructions for a scan to be performed the next day. When communicating the instructions, what should the technologist do to ensure that instructions will be understood by the patient?

A. visual contact between patient and self*
B. good posture
C. dress appropriately
D. occasional touching for emotional support

Problem 1: It requires only common sense and has only vague support for the correct answer

Problem 2: The best answer seems to be missing (asking the patient to restate the instructions)

Problem 3: The options are worded poorly

Problem 4: The stem is written in passive voice (“will be understood by”).

Solution: If the item is kept, it would need to be rewritten.

Appendix C – Style Sheet

These are the editorial conventions used in developing exams, which are necessary for consistency across the certification and registration categories.

Abbreviations

- Spell out units if not accompanied by a value
    - Example: Length can be measured in meters
- Do NOT use periods for most measurement abbreviations (e.g., mm, cm, ml, kg, ft, mph). Follow the AMA Manual of Style for specific exceptions.
- Use a.m. for time rather than AM or A.M.
- Follow AMA Manual of Style guidelines for vertebral and spinal nerve abbreviations:

Region	Vertebrae	Spinal nerves
cervical	C1 – C7	C1 – C8
thoracic	T1 – T12	T1 – T12
lumbar	L1 – L5	L1 – L5
sacrum	S1 – S5	S1 – S5
coccyx	4 fused, not designated individually	coccygeal

- Always specify the region when referring to a range of vertebrae
    - Example: C3 through C7 or 3rd through 7th cervical vertebrae
- Additional abbreviations specific to ARRT examinations:

Category	Abbreviation	Meaning
General	HVL	half-value layer
	TLD	thermoluminescent dosimeter
	SI	system international
Positioning	AP	anteroposterior
	PA	posteroanterior
	LAO	left anterior oblique
	LPO	left posterior oblique
	RAO	right anterior oblique
	RPO	right posterior oblique
Exposure Distances	OID	object-image receptor distance
	SID	source-image receptor distance
	SSD	source-skin distance

	SAD	source-axis distance
	SCD	source-collimator distance
	STD	source-tray distance
	SOD	source to object distance
unit Prefix	μ	micro – μSv, μCi
	m	milli – mL, mrem, mA
	c	centi – cm, cGy
	k	kilo – kV, kVp
	M	million – MV

Apostrophe

- Do NOT use an apostrophe with plural forms of years:
    - Example: 1700s, 1940s
- Do NOT use an apostrophe with plural numbers
    - Example: count by 5s
- Do NOT use an apostrophe with plural forms of acronyms
    - Example: UVs, ICBMs, RVs

Articles

- Keep articles with the stem unless the answer options require different articles (e.g., “a” vs. “an”)

Capitalization

- Capitalize negative words, such as NOT or EXCEPT, when used in the stem
- Proper names should be capitalized according to Dorland’s or Stedman’s Plus medical dictionaries
- The exception to this would be when referring to units of measure. Then the abbreviation is capitalized but when spelled out it is not. (Example – Gy versus gray)
- Eponyms (medical name derived from a person): When an eponym is included in the name of a disease, syndrome, sign, position, or similar designation, capitalize the eponym but NOT the common noun. Consult Dorland’s or Stedman’s Plus medical dictionaries.
    - Example: Chron disease

Contractions

- Do NOT use contractions in test items
    - Example: wasn’t, isn’t, can’t

Dates

- Use an en dash to link two numerals that represent a continuous sequence:
    - Example: January 9 – 14, 1869 – 1875
- Do not use an apostrophe with plural forms of years
    - Example: 1700s, 1940s

Exhibits

- If the exhibit came with labels, retain the use of whichever labels were on the original.
- If the exhibit is "clean," either numbers or letters are acceptable, but numbers may be the preferred choice to avoid confusion with the answer options
- The answer options should contain capitalized labels when included on the exhibit
    - Example: Part 1, Number 2, Organ 4, Arrow 5, Box 7
- Refrain from using the pound sign (#) with numbers.
    - Example: What is arrow 5 pointing to?
- Arrange arrows or alpha labels with an ascending order in a clockwise rotation
- Remove all patient identification from all exhibits, videos, and images
- Refer to exhibits in the item stem
    - Example: On MAM23, Arrow 3 points to…
- Do NOT name the type of exhibit (e.g., image, illustration)

Hyphenation

- Compound adjectives – hyphenation rules are many and confusing. Generally speaking, when compound adjectives are shown hyphenated in a dictionary, one can assume that the expression is only hyphenated when it occurs directly before a noun.
    - Hyphenated: "X-ray machine" and "single-phase generator"
    - NOT hyphenated: "the x rays were detected" and "operated on a single phase"
    - *Nonionic* NOT *non-ionic*
    - *Revascularization* NOT *re-vascularization*
    - *Multidetector* NOT *multi-detector*
    - EXCEPTION: *intra-aortic* NOT *intraaortic*
- In general, do NOT use a hyphen to set off a prefix at the beginning of a word or a suffix at the end of a word
- Use hyphens for negative signs
- Use hyphens for intervertebral spaces (including neural foramina) and intervertebral disks as follows:

Space	**Disk**
C2-3 (space between C2 and C3)	C2-3 disk
T2-3 (space between T2 and T3)	T2-3 disk
L2-3 (space between L2 and L3)	L2-3 disk

C7-T1 (space between C7 and T1)	C7-T1 disk
L5-S1 (space between L5 and S1)	L5-S1 disk

Initials

- Do NOT use spaces between the initials in proper names
    - Example: P.B.S. Pinchback

Italics

- Indicate use of italics in the "note" field on the item submission screen and indicate which areas (e.g., stem, options) that it applies to

Item Structure

- Do NOT use "a(an)"
- Do NOT use "all of the above" or "none of the above"
- Do NOT use "and/or"
- Do NOT use "is/are"
- Do NOT order answer options alphabetically
- Put numerical answer options in ascending order
- Align symbols and decimals vertically in numerical answer options
- Reserve the three-option multiple choice format for items that clearly have only three choices:

  Following the administration of contrast, and patient's temperature will:

  A. increase
  B. decrease
  C. remain constant

Negatives

- Avoid using "double negatives"
    - Example: All of these EXCEPT is NOT…
- Capitalize and bold negative terms in the stem

Numbers

- Do NOT use the word *to* between numerals
    - Example: January 11 – 16, pages 556 – 885, 1920 – 1945
- Use leading zeros for all decimal values
    - Example: 0.35 or -0.35
- Spell out numbers one through ten and numerals for 11 and above. When numbers below and above 11 are mixed in a stem, use numerals for all values.
- Use numerals in mathematical equations
- Use numerals to highlight measurements
    - Example: A rectangle measures 4 by 6 in.

- Use the multiplication symbol (×) rather than the letter X
    - Example: The screen resolution is 1024 × 768

Parallel Language

- Multiple choice item answer options must be syntactically consistent with the stem and each other
- Write options so that all options are independent, or as sets of opposite pairs
    - Example of successful opposites:

A. decrease frequency
B. increase frequency
C. increase velocity
D. decrease velocity

Percentages

- In text, spell out the word percent
- In charts, graphs, etc., use numerals and the percent symbol

Pronouns

- Pronouns must agree with their antecedent in number, gender, and person
- Avoid gendered pronouns (e.g., he, she, his, her) unless necessary to reach the correct answer

Punctuation

- Do NOT use terminal punctuation in item answer option
- Question marks that complete the stem should be placed outside of quotation marks
    - Example: What would you say to a patient who tells you “I am hungry”?
- Use a semi-colon to separate lists of steps or related thoughts in a single sentence.
- Always use the oxford (serial) comma
    - Example: The flag is red, white, and blue.
- Use a comma in numbers with four or more digits
    - Example: 3,589
- Use a comma (not semi-colon) to separate ordered pairs
    - Example: (2,3), (5,6), (8,9)
- Do NOT add a comma when numbers with multiple number places are spelled out: two thousand five hundred seventy-two

Ranges

- Repeat symbols for both values in a range
    - Example: 25% – 30% or 6” by 4”
- Only give the unit of measure once if spelled out or given as an abbreviation
    - Example: 9 by 12 feet

Spacing

- Use a single space between numerals and symbols denoting operations (e.g., addition, subtraction, multiplication, or division)

Spelling

- Consult Dorland's or Stedman's Plus medical dictionaries for spelling conventions
- Consult the PDR for spelling drug names
- Use generic drug names whenever possible

Symbols

- Use hyphens for negative signs
- Use appropriate accents in words or names
- Indicate use of special symbols in the "note" field and indicate what area (e.g., stem, options) that it applies to

Terminology

- Use generic terms rather than brand-name medications, manufacturer's-name medications, or vendor-specific equipment whenever possible
- If the generic term is not well known, use both the generic and brand name
- When you cannot use a generic term, state the scientific/generic name, include the trademark name in parenthesis, and include the correct symbol as defined by the manufacturer
    - Example: furosemide (Lasix®)
- In rare cases, the trademark will be the only appropriate and universally recognized name within that discipline
    - Example: Pigg-O-Stat™
- In some instances, you may use the industry-recognized term instead of the scientific name
    - Example: aspirin
- Use the PDR or manufacturer's website to determine the correct use of ™ or ®. If the medication, equipment etc. is used on the Content Outline, use that format
- Use the singular (datum) and plural (data) form where appropriate

Units of Measure

- Units of measurement associated with numbers should always be referenced in the stem and may be referenced in the options whenever possible.
    - Example Item:

    What is the amount of separation in centimeters between point A and point B

    A. 2 cm
    B. 3 cm
    C. 4 cm
    D. 5 cm

- Universally acceptable units

Unit	Meaning
cm	centimeters
m	meter
ft	foot, feet
L	liter
sec, s	second
hr	hour
A	amperes
mAs	milliampere seconds
V	volt
kVp	kilovolt peak
Hz	hertz
R	roentgen (SI unit is C/kg)
rad	radiation absorbed dose (SI unit is Gy)
rem	radiation equivalent man (SI unit is Sv)
Ci	curie (SI unit is Bq)
C/kg	coulombs per kilogram (conventional unit is R)
Gy	gray (conventional unit is rad)
Sv	sievert (conventional unit is rem)
Bq	becquerel (conventional unit is Ci)
mu	monitor units (Radiation Therapy)

- Spell out units if not accompanied by a value
    - Example: Length can be measured in meters
- Do NOT use periods for most measurement abbreviations (e.g., mm, cm, ml, kg, ft, mph). Follow the AMA Manual of Style for specific exceptions.
- Do NOT add an "s" to pluralize units of measure
    - Example: 3 sec NOT 3 secs

Verbs

- Verbs must agree with their subject in number and person

Appendix D – The Joint Commission "Do Not Use" List

In 2001, The Joint Commission issued a Sentinel Event Alert on the subject of medical abbreviations, and just one year later, its Board of Commissioners approved a National Patient Safety Goal requiring accredited organizations to develop and implement a list of abbreviations not to use. In 2004, The Joint Commission created its "do not use" list of abbreviations (see below) as part of the requirements for meeting that goal. In 2010, NPSG.02.02.01 was integrated into the Information Management standards as elements of performance 2 and 3 under IM.02.02.01.

Table 4. JRC Official "Do Not Use" List

Do Not Use	Potential Problem	Use Instead
U, u (unit)	Mistaken for "0" (zero), the number "4" (four), or "cc"	Write "unit"
IU (International Unit)	Mistaken for IV (intravenous) or the number 10 (ten)	Write "International Unit"
Q.D., QD, q.d., qd (daily)	Mistaken for each other	Write "daily"
Q.O.D., QOD, q.o.d., qod (every other day)	Period after Q mistaken for "I" and the "O" mistaken for "I"	Write "every other day"
Trailing zero (X.0 mg)*	Decimal point is missed	Write X mg
Lack of leading zero		Write 0.X mg
MS	Can mean morphine sulfate or magnesium sulfate	Write "morphine sulfate" Write "magnesium sulfate"
$MS04_4$ and $MgSO4_4$	Confused for one another	

*Exception: A "trailing zero" may be used only where required to demonstrate the level of precision of the value being reported, such as for laboratory results, imaging studies that report size of lesions, or catheter/tube sizes. It may not be used in medication orders or other medication-related documentation.

Contact the Standards Interpretation Group at (630) 792-5900, or complete the Standards Online Question Submission Form at http://www.jointcommission.org/Standards/OnlineQuestionForm/