

TO: The Senate

From: Talia Bugel, Chair  
Curriculum Review Subcommittee

Date: February 14, 2014

Subject: Bachelor of Science in Medical Imaging

The Curriculum Review Subcommittee met on January February 12, 2014 to review the attached proposal for a Bachelor of Science in Medical Imaging.

The committee finds that the proposed Bachelor of Science requires no Senate review.

Approving

Non-approving

Absent

Talia Bugel  
Ron Duchovic  
Craig Hill  
Rebecca Jensen  
Myeong Hwan Kim  
Susan Skekloff

Nancy Jackson (Sabbatical leave)  
Steve Sarratore (*ex officio*)

NEW PROGRAM PROPOSAL

BACHELOR OF SCIENCE IN MEDICAL IMAGING  
INDIANA UNIVERSITY-PURDUE UNIVERSITY FORT WAYNE  
August 2013

Institution: Indiana University–Purdue University Fort Wayne

College: Health and Human Services

Department: Medical Imaging

Degree Program Title: Bachelor of Science in Medical Imaging (BSMI)

Suggested CIP Code:

Location of Program: Fort Wayne, Indiana

Projected Date of Implementation: Fall 2014

Date Proposal was approved by  
Institutional Board of Trustees:

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Signature of Authorizing Institutional Officer

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Date

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Date Received by Commission for Higher Education

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Commission Action (Date)

# BACHELOR OF SCIENCE IN MEDICAL IMAGING DEGREE PROPOSAL

## Table of Contents

SECTION	CATEGORY	PAGE #
<b>1</b>	<b>Characteristics of the Program</b>	4
<b>2</b>	<b>Rationale for the Program</b>	4
	a. Institutional Rationale	4
	b. State Rationale	7
	c. Evidence of Labor Market Need	8
<b>3</b>	<b>Cost of and Support for the Program</b>	12
	a. Costs	12
	b. Support	14
<b>4</b>	<b>Similar and Related Programs</b>	15
	a. List of Programs and Degrees Conferred	15
	b. List of Similar Programs Outside Indiana	16
	c. Articulation of Associate/Baccalaureate Programs	17
	d. Collaboration with Similar or Related Programs on Other Campuses	17
<b>5</b>	<b>Quality and Other Aspects of the Program</b>	17
	a. Credit Hours Required, Time for Completion	17
	b. Exceeding the Standard Expectation of Credit Hours	18
	c. Program Competencies or Learning Outcomes	18
	d. Assessment	18
	e. Licensure and Certification	18
	f. Placement of Graduates	19
	g. Accreditation	20
<b>6</b>	<b>Projected Headcount, FTE Enrollments, Degrees Conferred</b>	20

<b>ATTACHED APPENDICES</b>		<b>PAGE #</b>
<b>1.1</b>	IPFW Mission, Values, Vision	22
<b>1.2</b>	IPFW Goals, Strategic Directions & Action	23
<b>1.3</b>	IPFW Baccalaureate Framework	24
<b>1.4</b>	IPFW BSMI Baccalaureate Framework Curriculum Grid	25-26
<b>1.5</b>	IPFW General Education Requirements	27-38
<b>1.6</b>	BSMI General Education Course List	39
<b>1.7</b>	JRCERT BSMI Radiography Curriculum Analysis	40-46
<b>1.8</b>	ASRT Curriculum Guide – Radiography	47-177
<b>1.9</b>	ASRT Curriculum Guide – Bachelor of Science – Rad. Science	178-260
<b>3.10</b>	Weeding Article – Degree Requirement & Employment	261-269
<b>3.11</b>	JRCERT Monthly Statistics	270
<b>4.12</b>	Interest in BSMI Degree at IPFW-Survey Response Summary	271
<b>4.13</b>	ASRT Job Bank, iHire Radiology, Indeed Job Search	272
<b>5.14</b>	Letters of Support	273-280
<b>7.15</b>	Cost of Equipment Installation	281
<b>8.16 - 1</b>	RPS Imaging Quote 1 – Konica CR	282-284
<b>8.16 - 2</b>	RPS Imaging Quote 2 – PACS	285-291
<b>10.17</b>	BSMI Four-Year Curriculum Sequence	292

**TO VIEW AN APPENDIX, CLICK ON APPENDIX LINK; TO RETURN, PRESS ALT – LEFT ARROW ON YOUR KEYBOARD.**



## Program Description

### **Bachelor of Science in Medical Imaging To Be Offered by Indiana University-Purdue University Fort Wayne, Indiana**

#### **1. Characteristics of the Program**

- a. Campus(es) Offering Program: **Indiana University-Purdue University Fort Wayne (IPFW)**
- b. Scope of Delivery (Specific Sites or Statewide): **IPFW only**
- c. Mode of Delivery (Classroom, Blended, or Online): **Blended**
- d. Other Delivery Aspects (Co-ops, Internships, Clinicals, Practica, etc.): **Clinicals and Practica**
- e. Academic Unit(s) Offering Program: **College of Health and Human Services, Department of Medical Imaging**

#### **2. Rationale for the Program**

##### **a. Institutional Rationale** (Alignment with Institutional Mission and Strengths)

- Why is the institution proposing this program?

**Indiana University-Purdue University Fort Wayne (IPFW) is proposing a Bachelor of Science in Medical Imaging (BSMI) degree to continue and enhance the education of medical imaging professionals in northeast Indiana.**

**In 2010, sponsorship of The Fort Wayne School of Radiography was transferred to IPFW with the intent that the associate degree curriculum would be appropriately modified to meet IPFW's role as a provider of university-level programs. Prior to the transition, the Fort Wayne School of Radiography had been affiliated with IPFW for more than 20 years. The affiliation offered students enrolled in the hospital-based certificate granting program the option to pursue the Associate of Science Degree at IPFW.**

**Since acquiring the program in 2010, Department faculty and University administrators have been modifying the associate degree curriculum to strengthen its alignment with University values and goals. The process of curriculum and program review has revealed that the associate degree in radiography at IPFW is no longer suitable to meet all of the general education and professional curriculum requirements within acceptable credit hour limits, and that offering a bachelor degree in medical imaging would better serve the IPFW, professional diagnostic imaging, and healthcare communities. The proposed baccalaureate program builds on the foundation of the current associate degree program, and meets the new state and university general education and degree credit hour requirements. The program will continue to develop medical imaging professionals with entry level discipline specific knowledge and skills, and will add value through broadened general education and expanded coursework and clinical practice in advanced medical imaging specialties, professional and inter-professional teamwork, and leadership.**

- How is it consistent with the mission of the institution?

**The mission of IPFW is to meet the higher education needs of those living in northeast Indiana through a broad range of undergraduate, graduate and continuing education programs that support regional needs and support excellence in teaching and learning (see Appendix 1.1: IPFW Mission, Values and Vision,pg 22). The Bachelor of Science in Medical Imaging will fulfill the higher education needs of individuals pursuing a career in radiologic technology, and offer expanded career opportunities for medical imaging professionals in the region.**

**The BSMI will be offered as a four-year degree program and also as a completion degree for radiologic technologists who have completed their education through a certificate or an associate degree program and are certified by the American Registry of Radiologic Technologists (ARRT). Students currently enrolled in the associate degree program at IPFW would be able to enter directly into the BSMI program if they choose to do so, while future students would enroll in the bachelor degree program from the beginning. The associate degree program would be phased out over time so that current students would have the opportunity to complete the program.**

**The proposed program will offer a degree completion option for those individuals who have completed a certificate or an associate degree in Radiologic Technology/Radiography at any appropriately accredited program, college or university, and who are certified by the ARRT with an entry level credential in Radiography. Students entering the program as a completion student (post certification option) must complete all general education and medical imaging courses and will be granted credit for courses completed in their professional education program. Credit may also be granted for clinical education courses based on clinical work experience, and for advanced imaging courses based on advanced certification credentials earned through the ARRT. A strength of the BSMI completion degree component would be its ability to articulate with associate degree radiography programs throughout Indiana, such as Ivy Tech Community College, as well as the United States for transfer of credits toward a baccalaureate degree.**

- How does this program fit into the institution's strategic and/or academic plan?

**Although the associate degree program currently supports aspects of IPFW's strategic and academic plans, the implementation of the BSMI degree would offer a fit more closely aligned with several of the goals and priorities outlined in the *IPFW Strategic Plan 2008-2014* (see Appendix 1.2: IPFW Goals, Strategic Directions and Action Priorities,pg 23). Some specific examples of IPFW values and priorities stated in the *IPFW Strategic Plan 2008-14* supported by the implementation of the BSMI degree include:**

- 1. Provide a strong general education program and baccalaureate framework that emphasize critical thinking, promote lifelong learning and continue the traditions of the sciences, arts, and humanities.***
- 2. Structure undergraduate curricula to assure that students achieve the learning goals established in the IPFW Baccalaureate Framework.***

- 3. Increase student research, internships, study abroad, international experiences, Honors Program participation, and other forms of experiential learning.*

The proposed BSMI has been developed with the IPFW Baccalaureate Framework as its foundation. The expanded curriculum of the bachelor degree contains the IPFW General Education components that support the traditions of a liberal arts education

(see Appendix 1.3: IPFW Baccalaureate Framework, pg 24;

Appendix 1.4: IPFW BSMI Baccalaureate Framework Curriculum Map, pg 25;

Appendix 1.5: IPFW General Education Requirements pg 27; and

Appendix 1.6: BSMI General Education Course List, pg 39). It is through the expansion of the curriculum that the program will be able to meet the desired outcome of providing a strong general education while continuing to meet the educational goals and objectives of the profession as shown in the Curriculum Analysis Grid based upon the American Society of Radiologic Technologists (ASRT) Curriculum Guide

(see Appendix 1.7: JRCERT BSMI Radiography Curriculum Analysis, pg 40;

Appendix 1.8: ASRT Curriculum Guide – Radiography, pg 47; and

Appendix 1.9: ASRT Curriculum Guide - Bachelor of Science in Radiologic Sciences, pg 178.)

The BSMI curriculum and coursework will also offer students a greater opportunity to participate in research and international experiences and to participate in the IPFW Honors Program.

- 4. Establish new undergraduate programs to meet emerging regional needs and student interests.*

Surveys of current IPFW pre-radiography and radiography students, as well as medical imaging professionals who are currently employed in the IPFW area, show that there is interest in a BSMI degree at IPFW. Please refer to section 2. c. v. on page 9 for a summary of the surveys conducted.

- 5. Expand the number of articulation and transfer agreements with Ivy Tech Community College and increase participation in agreements.*

The proposed BSMI would offer the opportunity for students who have earned the associate of science degree in Radiologic Technology at an Ivy Tech campus to enter and complete the bachelor degree program at IPFW.

- How does this program build upon the strengths of the institution?

The BSMI degree will contribute to and expand the strong community partnerships that IPFW upholds and desires to cultivate. The program will maintain and grow relationships with various health care facilities in the community as clinical experience sites for students, and will develop opportunities for partnerships with health care organizations related to professional development, leadership and service.

The IPFW BSMI degree will build upon the strength of the partnership between Indiana University and Purdue University. Students who graduate with a BSMI

degree from IPFW will benefit not only from the resources offered at IPFW, but also from educational resources available through the Indiana University School of Medicine as well as resources available through the Purdue University School of Health Sciences. This unique combination of accessible resources and opportunities for collaboration will support IPFW's efforts to develop distinctive programs and sustain its tradition of excellence.

*Appendix 1: Institutional Rationale, Detail (This appendix should contain links to the institution's strategic and / or academic plan or the plans themselves)*

**Appendix 1.1, pg 22 - IPFW Mission, Values and Vision**

**Appendix 1.2, pg 23 - IPFW Goals, Strategic Directions and Action Priorities**

**Appendix 1.3, pg 24 - IPFW Baccalaureate Framework**

**Appendix 1.4, page 25 - IPFW BSMI Baccalaureate Framework Curriculum Grid**

**Appendix 1.5, pg 27 - IPFW General Education Requirements**

**Appendix 1.6, pg 39 - BSMI General Education Course List**

**Appendix 1.7, pg 40 - BSMI Curriculum Analysis Grid**

**Appendix 1.8, pg 47 - ASRT Curriculum Guide - Radiography**

**Appendix 1.9, pg 178 - ASRT Curriculum Guide - Bachelor of Science in Radiologic Sciences**

**b. State Rationale**

- How does this program address state priorities as reflected in *Reaching Higher, Achieving More*?

**The BSMI degree addresses a number of the state priorities reflected in *Reaching Higher, Achieving More* ([http://www.in.gov/che/files/2012\\_RHAM\\_8\\_23\\_12.pdf](http://www.in.gov/che/files/2012_RHAM_8_23_12.pdf)). This degree will:**

- **increase the knowledge, skills and level of degree attainment needed for satisfactory lifetime employment in the field of medical imaging.**
- **create an efficient, affordable pathway for students to complete a baccalaureate degree in a timely manner.**
- **offer a seamless transfer of associate degree credits from community colleges and other universities toward completion of baccalaureate degree requirements.**
- **implement general education requirements that will meet the standards of the statewide general education common core curriculum.**
- **maintain academic quality and a standard of academic excellence valued by the medical imaging profession and assured by programmatic accreditation from the Joint Review Committee on Education in Radiologic Technology.**

- provide a return on investment for graduates through national exam certification pass rates and job placement rates that meet or exceed the national average. (for published IPFW program data see JRCERT Program Effectiveness Data at <https://portal.jrcertaccreditation.org/summary/programannualreportlist.aspx>)

c. **Evidence of Labor Market Need**

i. National, State, or Regional Need

- Is the program serving a national, state, or regional labor market need?

**Employment opportunities for radiographers exist in Indiana as well as throughout the United States. The IPFW BSMI degree will focus on serving state and regional labor market needs, but will also provide graduates who are capable of meeting the national labor market needs for certified radiographers and qualified post-primary advanced certification candidates.**

**Beginning in 2013, candidates sitting for the ARRT Radiography Certification Examination will be measured by a new, higher standard. The new standard requires individuals to answer more questions correctly in order to pass the national exam and achieve certification. The more comprehensive curriculum of the BSMI degree will facilitate the continued success of program graduates in passing the ARRT Radiography Certification Examination.**

**Additionally, beginning in 2016, the ARRT will enact a structured education requirement for candidates who wish to pursue post-primary advanced certification. The structured education requirement will mean that certified radiographers will no longer be allowed to achieve advanced certification in special imaging areas such as CT, MRI, Quality Management, and PACS Administration without at least 16 hours of structured education. At the same time, due to reimbursement policies for diagnostic imaging services, many employers are requiring that technologists hold advanced certification credentials in order to work in special imaging modalities. The credential requirement from employers means that technologists may not qualify for positions in certain areas of imaging. The courses offered in the BSMI curriculum will fulfill selected structured education requirements for current students and/or certified radiographers who aspire to attain advanced post-primary certification and progress in their career.**

ii. Preparation for Graduate Programs or Other Benefits

- Does the program prepare students for graduate programs or provide other benefits to students besides preparation for entry into the labor market?

**The academic rigor of the BSMI degree will prepare graduates for admission into graduate programs. A student who graduates with a BSMI degree would have the option to pursue a Master of Science in Radiologic Sciences, a Radiologist Assistant Master of Science, or a Physician Assistant Master of Science. Other appropriate fields of graduate study include degrees in healthcare administration, healthcare information systems, adult education, and organizational leadership and supervision.**

iii. Summary of Indiana DWD and/or U.S. Department of Labor Data

- Summarize the evidence of labor market demand for graduates of the program as gleaned from employment projections made by the Indiana Department of Workforce Development and/or the U.S. Department of Labor?

The radiologic technology profession is listed 38<sup>th</sup> on the Indiana Department Workforce Development's 50 Hottest Jobs website ([www.in.gov/dwd](http://www.in.gov/dwd)). The 2012-2013 U.S. Department of Labor's *Occupational Outlook Handbook* (OOH) (<http://www.bls.gov/ooh/healthcare/radiologic-technologists.htm>) indicates employment for radiologic technologists is expected to grow by 28% between 2010 and 2020; faster than the average of 14.3% for all occupations. According to OOH, this increase will be the result of a number of issues.

- An increasing aging population will result in an increase in medical conditions that require imaging.
- The shift toward increasing outpatient care will offer new job opportunities as physician offices and outpatient imaging centers begin to offer more diagnostic imaging services.
- Indiana and most of the United States require that only a certified radiologic technologist may operate diagnostic imaging equipment.

*Appendix 2: Summary of Indiana DWD and/or U.S. Department of Labor Data, Detail* (This appendix should contain the detailed tables, upon which the summary of the labor market demand is based.)

National Employment Projections for Radiologic Technologists, 2010-2020	
Number of Jobs, 2010	219,900
Employment Change, 2010-20	61,000
Job Outlook, 2010-20	+ 28%

Source: U.S. Bureau of Labor Statistics, Occupational Outlook Handbook

Indiana Employment Projections for Radiologic Technologists, 2008-2018	
2008 Employment	5,002
2018 Employment Projections	6,360
Percentage of Change, 2008-18	+ 27%

Source: Indiana Department of Workforce Development

iv. National, State, or Regional Studies

- Summarize any national, state, or regional studies that address the labor market need for the program.

**In 2009, the American Registry for Radiologic Technologists (ARRT) approved new education requirements for certification examination applicants. Effective January 2015, candidates applying to take the examination for certification in Radiography must have earned an Associate, Bachelor, or Graduate Degree. Currently, candidates who have earned a certificate may also apply to take the ARRT examination.**

**In a recent study, data reveals that certificate-based programs have not fully reacted to the changes coming in 2015, and that many programs have not made the necessary changes to offer an associate degree (see Appendix 3.10: Weening, pg 261). According to Weening's data, as of May of 2011 27% (192/718) of radiography programs in the United States still offered a certificate as the highest award upon graduation. In addition, statistics published in July 2013 support the data in Weening's study, showing that approximately 27% of Radiography programs accredited by the JRCERT still offer a certificate upon graduation (see Appendix 3.11: JRCERT Monthly Statistics, pg 270). Although there is no way to predict with certainty how the labor market will be effected by the change in education requirements, the data supports the notion that perhaps some programs do not intend to meet the new requirement and may discontinue. Therefore, this increase in education requirements is predicted to result in a greater increase in employment opportunities for radiologic technologists than is projected by the Bureau of Labor Statistics.**

**Weening's study also indicates that in 2011 only 6% of radiologic technology programs offered a baccalaureate degree, and the July 2013 statistics show that only 6% of JRCERT accredited programs currently offer a bachelor degree. The data supports the need for bachelor degree /bachelor completion programs in medical imaging that will offer students the opportunity to gain additional knowledge and skills related to aspects such as patient care, teamwork, and additional areas of imaging; thus offering graduates greater employment opportunities.**

***Appendix 3: National, State, or Regional Studies, Detail (This appendix should contain links to the studies cited or the studies themselves.)***

**Appendix 3.10, page 261:**

**Weening, Richard H., *Degree Requirement & Employment Opportunity in Radiologic Science*, Radiologic Technology, July / August 2012.**

**Appendix 3.11, pg 270 - JRCERT Monthly Statistics**

v. Surveys of Employers or Students and Analyses of Job Postings

- Summarize the results of any surveys of employers or students and analyses of job postings relevant to the program.

**In Fall of 2012 and Spring of 2013, three (3) surveys were conducted for the purpose of determining student and professional community interest in a BSMI degree at IPFW. In November 2012, an initial survey was sent to 154 current IPFW students who had declared majors in pre-radiography and radiography with 55 responses received, resulting in a 36% response rate. In March 2013, a follow-up survey was sent to the same 154 students with 36 responses received, resulting in a 23% response rate. A survey was also sent in March 2013 to 152 registered technologists who are currently working in the IPFW area with 44 responses received, resulting in a 29% response rate.**

**The surveys of current students show that of those who responded, 98% of students plan to pursue a bachelor degree on a full time (51%) or part time (47%) basis after completing an associate degree, and that 94% would pursue a bachelor degree at IPFW rather than an associate degree elsewhere.**

**The surveys of technologists reveal that of the respondents, 86% have achieved an associate degree as the highest level of education, that 38% would be interested in pursuing a bachelor degree at IPFW, and that 93% would have chosen to pursue a bachelor degree at IPFW rather than an associate degree elsewhere**

**(see Appendix 4.12: Interest in BSMI Degree at IPFW – Survey Response Summary, pg 271).**

**Local, state, and national job postings for radiologic technologists indicate that the majority of employment opportunities for entry level radiographers and advanced imaging practitioners are clinical positions in hospitals and outpatient centers**

**(see Appendix 4.13:**

**ASRT Job Bank, iHireRadiology, Indeed Job Search, pg 272).**

***Appendix 4: Surveys of Employers or Students and Analyses of Job Postings, Detail* (This appendix should contain links to the surveys or analyses cited, or the documents themselves.)**

**Appendix 4.12, page 271:**

**Interest in BSMI Degree at IPFW – Survey Response Summary**

**Links to radiologic technology job postings: Appendix 4.13, pg 272:  
Employment Opportunities in Radiography**

**ASRT Job Bank – <http://www.healthcareers.com/asrt>**

**iHireRadiology - <http://www.ihireradiology.com/jobs/radiology-technologist-jobs/states>**

**Indeed Job Search - <http://www.indeed.com/q-Radiologic-Technologist-jobs.html>**



vi. Letters of Support

- Summarize, by source, the letters received in support of the program.

**Letters of support for the proposed BSMI degree were requested from the medical imaging professionals listed below. As imaging practitioners, they are able to address the educational requirements for radiologic technologists and the increasing complexity of the medical imaging field.**

<b>Name</b>	<b>Title</b>	<b>Institution/Corporation</b>
<b>Karen Brehm, BS, R.T.(R)</b>	Operations Manager, Radiology	St. Joseph Hospital, Fort Wayne, IN
<b>Joy Cook, MS, R.T.(R)(CT)(MRI)</b>	Clinical Assistant Professor & Clinical Coordinator	University of Southern Indiana, Evansville, IN
<b>Bonnie Doerffler, BS, R.T.(R)(M)</b>	Operations Manager, Diagnostic Imaging	Parkview Hospital , Fort Wayne, IN
<b>Dr. Michael Kinzer, MD</b>	Radiologist	Fort Wayne Radiology, Fort Wayne, IN
<b>Dr. Sal Martino, Ed.D., R.T.(R), CAE</b>	Chief Executive Officer	American Society of Radiologic Technologists, Albuquerque, NM
<b>Dr. David Powell, MD</b>	Radiologist	Fort Wayne Radiology, Fort Wayne, IN

***Appendix 5: Letters of Support, Detail** (This appendix should contain the letters of support for the program.)*

**Appendix 5.14, page 273: Letters of support**

**3. Cost of and Support For the Program**

**a. Costs**

**i. Faculty and Staff**

- Of the faculty and staff required to offer this program, how many are in place now and how many will need to be added (express both in terms of number of full- and part-time faculty and staff, as well as FTE faculty and staff)?

**The IPFW Radiography Program currently maintains three full-time and one part time (0.7) faculty positions for a total of 3.7 FTE faculty positions. One full-time faculty position is allocated to the program chair whose position is 50% teaching and 50% administrative. One full-time faculty position is allocated to the clinical director whose position is also 50% teaching and 50% administrative. The remaining 1.7 FTE faculty positions are dedicated fully to teaching. The program maintains one full-time, 1.0 FTE, secretary position of which 90% is dedicated to support the Department of Radiography and 10% is dedicated to support the College of Health and Human Services.**

**The Program is requesting an additional 0.3 FTE faculty position for a total of 4.0 FTE faculty positions to support the implementation of the BSMI degree.**

***Appendix 6: Faculty and Staff, Detail*** (This appendix should contain a list of faculty with appointments to teach in the program and a brief description of new faculty positions yet to be filled.)

<b>Full-time Faculty</b>	<b>Titles</b>
<b>Cheryl Duncan, M.S., R.T.(R)(QM)</b>	Chair & Clinical Assistant Professor, Department of Radiography
<b>Michelle Frtiz, M.S.Ed., R.T.(R)</b>	Clinical Director & Clinical Assistant Professor, Department of Radiography
<b>Mari Sanders, M.S., R.T.(R)(M)</b>	Clinical Assistant Professor, Department of Radiography
<b>Proposed Full-time Faculty position (requires additional 0.3 added to the Part-time position below)</b>	Clinical Assistant Professor, Department of Radiography This position will require an advanced certification
<b>Part-time Faculty</b>	<b>Title</b>
<b>Lisa Schaefer, M.B.A, R.T.(R) (this Part-time position will be altered to the Full-time position listed above)</b>	Clinical Assistant Professor, Department of Radiography

ii. Facilities

- Summarize any impact offering this program will have on renovations of existing facilities, requests for new capital projects (including a reference to the institution’s capital plan), or the leasing of new space.

**The program currently maintains one dedicated x-ray lab and classroom, and is requesting one additional x-ray lab and classroom to support the BSML. The x-ray equipment has already been donated to the IPFW Department of Radiography for this purpose and is being stored on campus.**

**At present, scheduling conflicts occasionally occur due to having one lab and two cohorts of students; the additional lab and classroom space will alleviate greater scheduling complications caused by the enhanced curriculum and sharing a single lab and classroom space with three cohorts of students.**

**As the medical imaging profession is highly procedurally focused, it is**

essential that students have the opportunity to actively practice radiographic procedures and patient care in a simulated clinical environment. The additional lab and classroom space will allow scheduling of didactic courses, laboratory demonstrations, practical examinations, and clinical experience for each cohort of students in an effective manner.

The existing equipment would be installed in a large classroom on campus with no additional radiation safety construction required as the equipment would be for positioning lab purposes only, and would not be energized to produce x-rays. The cost associated with the installation of the equipment would be approximately \$35,000-\$40,000 (see Appendix 7.15, pg 281).

*Appendix 7: Facilities, Detail*

**Appendix 7.15, page 281: Cost Estimate from IPFW Project Manager**

iii. Other Capital Costs (e.g. Equipment)

- Summarize any impact offering this program will have on other capital costs, including purchase of equipment needed for the program.

**Additional equipment needed to support the expanded curriculum of the BSMI degree includes a Picture Archiving and Communication System (PACS), Radiography Information System (RIS), and digital image processing equipment. The information system could be integrated with the current Electronic Health Record System utilized by the IPFW Department of Nursing allowing for inter-professional education opportunities. The approximate cost of digital processing equipment and required support system hardware and software is \$40,000 (see Appendix 8.16, pg 282).**

*Appendix 8: Other Capital Costs, Detail*

**Appendix 8.16, pg 282: Quotes from RPS Imaging**

**b. Support**

i. Nature of Support (New, Existing, or Reallocated)

- Summarize what reallocation of resources has taken place to support this program.

**Reallocation of the part-time Radiography Faculty position will be required to fulfill the personnel needs.**

- What programs, if any, have been eliminated or downsized in order to provide resources for this program?

**No programs will be eliminated in order to provide resources for this program.**

ii. Special Fees above Baseline Tuition

- Summarize any special fees above baseline tuition that are needed to support this program.

**Students in the radiography program currently pay an annual fee for clinical tracking software. The annual fee is \$130.00 per student. The students are responsible for half of the fee (\$65.00) and the program is responsible for the other half (\$65.00). The electronic tracking system enables students to submit and store all clinically related documents including but not limited to: clinical compliance, clinical evaluations, clinical experience hours, clinical examination log, and clinical procedure competency. Students can utilize the data to create a portfolio of clinical experience gained during their education to complete documentation of clinical competency requirements for advanced certification and to share with potential employers or graduate programs. This fee will continue with the proposed BSMI program.**

#### **4. Similar and Related Programs**

##### **a. List of Programs and Degrees Conferred**

###### **i. Similar Programs at Other Institutions**

Campuses offering (on-campus or distance education) programs that are similar:

- CHE staff will summarize data from the Commission's Program Review Database on headcount, FTE, and degrees conferred for similar programs in the public sector, as well as information on programs in the non-profit and proprietary sectors, to the extent possible. *CHE Appendix A: Similar Programs at Other Institutions, Detail (This appendix will contain back-up tables for the summary.)*
- Institutions may want to supplement this data with supplementary contextual information, such as relevant options or specializations or whether or not programs at other institutions are accredited or lead to licensure or certification.

**Relatively few programs across the country offer a baccalaureate degree in radiography or medical imaging. The majority of baccalaureate degree programs that do exist are designed as one-plus-two-plus-one programs in which students have the option to complete a bachelor degree after completing a three year associate degree. A concern with implementing this curriculum design at IPFW is that the professional curriculum plus the required general education credits would result in a 97 credit hour associate degree. The proposed IPFW bachelor curriculum was specifically designed to address the concern of the overcrowded curriculum of the associate degree and to include expanded content in both the professional**

curriculum and general education curriculum within acceptable credit hour guidelines; thereby appropriately meeting state and university guidelines as well as the needs of IPFW students and the medical imaging profession. In Indiana, IPFW's bachelor degree would be one of two programs to offer students direct admission to a bachelor degree in medical imaging, as well as the completion option for those individuals who have already completed an associate degree in radiography.

Currently Indiana offers baccalaureate degrees and/or baccalaureate completion degree programs at the institutions listed below.

Institution	Degree Conferred
Indiana University – Purdue University <i>Indianapolis</i>	Bachelor of Science in Medical Imaging Technology
	• Completion degree
Indiana University <i>Kokomo</i>	Bachelor of Science in Medical Imaging Technology
	• Completion degree
Indiana University <i>Northwest</i>	Bachelor of Science – Clinical/Health Management Concentration for Radiographers
	• Completion degree
Indiana University <i>South Bend</i>	Bachelor of Science in Medical Imaging Technology
	• Completion degree
University of Southern Indiana	Bachelor of Science in Radiologic and Imaging Sciences
	• Four-year degree • Completion degree

ii. Related Programs at the Proposing Institution

- CHE staff will summarize data from the Commission's Program Review Database on headcount, FTE, and degrees conferred for related programs at the proposing institution. *CHE Appendix B: Related Programs at the Proposing Institution, Detail (This appendix will contain back-up tables for the summary.)*

b. List of Similar Programs Outside Indiana

- If relevant, institutions outside Indiana (in contiguous states, MHEC states, or the nation, depending upon the nature of the proposed program) offering (on- campus or distance education) programs that are similar:

According to the July 2013 JRCERT monthly statistics, 37 out of 633 (6%) JRCERT accredited programs offer a bachelor degree in radiography (see Appendix 3.11: JRCERT Monthly Statistics, pg 270).

c. Articulation of Associate/Baccalaureate Programs

- For each articulation agreement, indicate how many of the associate degree credits will transfer and apply toward the baccalaureate program.

**There are no articulation agreements with other radiography programs at this time; however, it is anticipated that all or most courses completed at accredited colleges and universities will transfer into this degree. Students who have completed associate degrees at other institutions must first apply and be accepted at IPFW to be considered for admission to the BSMI. The IPFW Office of Admissions will be a valuable resource in determining course equivalencies for general education courses transferred from other colleges and universities. Radiography professional courses must have been completed at a JRCERT or regionally accredited program in the United States.**

**The radiography associate degree curricula offered at Indiana University campuses and Ivy Tech Community College are similar to the IPFW curriculum. Transferability of courses completed in those programs should be relatively seamless.**

***Appendix 9: Articulation of Associate/Baccalaureate Programs, Detail***  
(This appendix should contain the actual articulation agreements relevant to the proposed program.)

d. Collaboration with Similar or Related Programs on Other Campuses

- Indicate any collaborative arrangements in place to support the program.

**There are no collaboration arrangements with other campuses at this time.**

5. Quality and Other Aspects of the Program

a. Credit Hours Required/Time To Completion

- Credit hours required for the program and how long a full-time student will need to complete the program.

**The BSMI degree requires the completion of 120 credit hours and can be completed by a full-time student in four years. Completion degree student transcripts will be evaluated on an individual basis to determine coursework required for each student.**

***Appendix 10: Credit Hours Required/Time To Completion, Detail*** (This appendix should contain the semester-by-semester, course-level detail on the program)

*curriculum, including how long it will take to complete the program, assuming full-time study.)*

**Appendix 10.17, page 292: BSMI Four-Year Curriculum Sequence**

**b. Exceeding the Standard Expectation of Credit Hours**

- If the associate or baccalaureate degree program exceeds 60 or 120 semester credit hours, respectively, summarize the reason for exceeding this standard expectation.

**Not applicable.**

**Appendix 11: Exceeding the Standard Expectation of Credit Hours, Detail**

**Not applicable.**

**c. Program Competencies or Learning Outcomes**

- List the significant competencies or learning outcomes that students completing this program are expected to master.

**Learning Outcomes for the Bachelor of Science in Medical Imaging**

**A graduate of the program will be able to:**

- **Demonstrate effective interpersonal communication with patients and healthcare staff.**
- **Demonstrate critical thinking skills through determination of logical film sequence and procedural variations for non-routine situations.**
- **Evaluate the quality of radiographic images.**
- **Demonstrate clinical procedural proficiency and radiation safety.**
- **Demonstrate age specific radiographic patient care.**
- **Demonstrate effective written communication and oral communication skills.**
- **Demonstrate professional and ethical behaviors in clinical practice.**
- **Demonstrate appropriate response to medical emergency situations.**
- **Demonstrate an aptitude for leadership and teamwork in a healthcare setting.**

**d. Assessment**

- Summarize how the institution intends to assess students with respect to mastery of program competencies or learning outcomes.

**The IPFW Department of Medical Imaging will continue to submit annual assessment reports to the JRCERT, the College of Health and Human Services assessment committee, and the campus assessment committee. Assessment data will be used to determine the overall success of the program and target areas for improvement. Assessment measures will include evaluation of student learning outcomes listed in section 5.c. as well as assessment of program outcomes such as program completion rate, ARRT pass rate and job placement rate. Assessment tools such as graduate and employer surveys will be used in the evaluation process.**

e. Licensure and Certification

Graduates of this program will be prepared to earn the following:

- State License:

**State licensure from the Indiana State Department of Health is granted upon successful completion of the national American Registry on Radiologic Technology (ARRT) examination. Most of the United States grant licensure upon the successful completion of the ARRT examination; however, there are a few states (California, New York ) that require an additional state license test for which our program will also prepare students.**

- National Professional Certifications (including the bodies issuing the certification):

- **Graduates of the program will have completed the didactic and clinical eligibility requirements for the Primary Certification in Radiography from the ARRT.**
- **Graduates of the program will have completed the didactic eligibility requirements that will allow them to pursue Advanced Certification in in areas such as Computed Tomography and Quality Management.**
- **Graduates of the program may, through proper course planning, be eligible to pursue certification from the American Board of Imaging Informatics (ABII).**

- Third-Party Industry Certifications (including the bodies issuing the certification):

**Completion of the BSMI Degree will support preparation for the Certified Radiology Administrator (CRA) examination from the Radiology Administration Certification Commission.**

f. Placement of Graduates

- Please describe the principle occupations and industries, in which the majority of graduates are expected to find employment.

**The majority of graduates are expected to work in hospital imaging departments; in addition, graduates of the BSMI degree will be eligible for employment in**

- **outpatient imaging clinics**
- **outpatient surgery centers**
- **outpatient pain management centers**
- **urgent care centers**
- **mobile radiography**
- **medical imaging programs (as entry level clinical &/or didactic instructors)**
- **medical products corporations**



- If the program is primarily a feeder for graduate programs, please describe the principle kinds of graduate programs, in which the majority of graduates are expected to be admitted.

**This program will not be utilized as a feeder for graduate programs. However, BSMI graduates will be eligible for admission into the advanced degree programs such as**

- **adult education, including medical imaging education**
- **health administration**
- **business administration**
- **organizational leadership and supervision**
- **advanced clinical imaging modalities**
- **advanced clinical radiologist assistant**
- **physician assistant**
- **medical/health informatics**

**g. Accreditation**

- Accrediting body from which accreditation will be sought and the timetable for achieving accreditation.

**The IPFW Radiography Program is fully accredited by the Joint Review Committee on Education in Radiologic Technology (JRCERT). Radiography programs are required to notify the JRCERT in writing prior to the initiation of substantive changes. The IPFW Department of Radiography has verbally notified the JRCERT of the intent to submit a Bachelor degree proposal and will notify the JRCERT in writing upon approval, if granted.**

- Reason for seeking accreditation.

**Graduation from a JRCERT accredited program demonstrates that a student has met an academic standard of excellence valued by the medical imaging profession. Graduation from a JRCERT accredited program is required by some employers.**

**6. Projected Headcount and FTE Enrollments and Degrees Conferred**

- Report Headcount and FTE enrollment and degrees conferred data in a manner consistent with the Commission’s Student Information System  
**See table provided in this section.**
- Report a table for each campus or off-campus location at which the program will be offered  
**Not applicable.**
- If the program is offered at more than one campus location, a summary table, which reports the total headcount and FTE enrollments and degrees conferred across all locations, should be provided. **Not applicable.**

- Round the FTE enrollments to the nearest whole number.
- If the program will take more than five years to be fully implanted and to reach steady state, report additional years of projections.  
**Not applicable.**

**Date: July 2013**

**Institution/Location:** Indiana University-Purdue University/Fort Wayne, IN

**Program:** Radiography

<b>Enrollment Projections (Headcount)</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>
	<b>FY2014</b>	<b>FY2015</b>	<b>FY2016</b>	<b>FY2017</b>	<b>FY2018</b>
Full-time AS RAD students	40	20	0	0	0
Full-time BSMI students	5	25	50	60	60
Part-time BS completion students	5	10	10	10	10
<b>Total</b>	<b>50</b>	<b>55</b>	<b>60</b>	<b>70</b>	<b>70</b>

<b>Enrollment Projections (FTE)</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>
Full-time AS RAD students	40	20	0	0	0
Full-time BSMI students	5	25	50	60	60
Part-time BS completion students	3	5	5	5	5
<b>Total</b>	<b>48</b>	<b>50</b>	<b>55</b>	<b>65</b>	<b>65</b>

<b>Degrees Conferred Projections</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>
AS RAD degrees	20	20	0	0	0
BSMI degrees	5	7	7	25	25
<b>Total</b>	<b>25</b>	<b>27</b>	<b>7</b>	<b>25</b>	<b>25</b>

CHE Code:12-XX

Campus Code: XXXX

County: Allen

Degree Level: BS

CIP Code: Federal – 000000; State - 000000

## IPFW - Mission, Values, and Vision

### Mission

IPFW's mission is to meet the higher education needs of northeast Indiana. We offer a broad range of high-quality undergraduate, graduate, and continuing education programs that meet regional needs, support excellence in teaching and learning, advance and share knowledge through research and creative endeavor, and work with the community to develop intellectual, cultural, economic, and human resources.

### Values

We are committed to excellence in teaching, student learning, research and creative endeavor, and regional development. As such, IPFW values:

- the pursuit of knowledge in an environment that encourages free and open inquiry, academic achievement, scholarship, and creativity.
- a strong general education program and baccalaureate framework that emphasize critical thinking, promote lifelong learning, and continue the traditions of the sciences, arts, and humanities.
- a commitment to student access and success that is demonstrated through services and student life programs responsive to individual needs and interests.
- a campus environment that promotes integrity, respect for diversity, responsible citizenship, accountability, sustainability, and continuous improvement.
- the principles of shared governance, civility, and open communication among all groups within the university.
- the traditions of scholarly excellence and public engagement of Indiana University and Purdue University.
- the professional commitment, innovations, and accomplishments of faculty and staff.
- partnership with the community to enhance social, economic, cultural, civic, and intellectual life in the region.

### Vision

IPFW will be a nationally recognized university, known for its regional impact and:

- the excellence, value, and accessibility of its academic programs.
- an exceptional environment for teaching, learning, and student achievement.
- the scholarly and creative accomplishments of its faculty, students, and staff.
- its contributions to the quality of life of the region.

## IPFW Goals, Strategic Directions, and Action Priorities

- Goals, Strategic Directions, and Action Priorities

### **Goal 1: Foster Learning and Create Knowledge**

Fostering learning and creating knowledge lie at the heart of the university's mission. Achieving the goal requires attracting and retaining a highly qualified faculty, providing support, regularly assessing and improving program quality, employing pedagogies that improve student learning, expanding academic support programs, and enhancing research and creative activity for faculty, staff, and students.

Strategic Directions and Action Priorities

1. Attract, support, and celebrate a highly qualified and diverse faculty and staff.
2. Offer a broad array of graduate and undergraduate programs that meet the highest standards of their disciplines and respond to regional needs.
3. Promote the use of multiple methods of teaching and delivery to expand access and improve student learning and success.
4. Assure quality and effectiveness of academic programs through accreditation, program review, and assessment of student learning.
5. Expand academic support for a diverse community of learners to facilitate student success and create a culture of graduation.
6. Promote and support faculty research/creative activity and increase external funding.

### **Goal 2: Develop Quality of Place and Experience**

Quality of place is a view of the university campus as a community of learners connected by a commitment to academic achievement and shared values. It is enhanced through a philosophy of inclusion that recognizes the strengths inherent in the diversity of faculty, staff, and students. It is experienced through participation in programs and events important to members of the campus community.

Strategic Directions and Action Priorities

1. Increase student enrollment in a steady and sustainable manner toward the goal of 15,000 students.
2. Promote IPFW as an inclusive university community of students, staff, faculty, and alumni as well as members of their families.
3. Encourage personal and professional development for all members of the university community.
4. Continuously re-engineer infrastructure and services to improve support for students, faculty, staff, and others who interact with IPFW.
5. Improve and expand physical facilities and campus grounds.
6. Enhance financial support for university programs and services.

### **Goal 3: Contribute to the Development of the Northeast Indiana Region**

IPFW sponsors educational, cultural, and recreational opportunities for community audiences of all ages and engages in projects with regional businesses that improve their sustainability and competitiveness. Targeted projects are built upon active communication with the community, an entrepreneurial spirit, and cooperative investments. IPFW seeks to provide intellectual leadership by stimulating debate, modeling diversity, and providing expertise to community partners.

Strategic Directions and Action Priorities

- Engage and enrich the community through programs hosted on campus and through the campus environment.
- Provide and extend university expertise, services, and support throughout northeast Indiana.
- Enhance regional economic development.

## IPFW Baccalaureate Framework

### Framework for the IPFW Baccalaureate Degree

Students who earn a baccalaureate degree at IPFW will be able to apply their knowledge to the needs of an increasingly diverse, complex, and dynamic world. To that end, IPFW continually develops and enhances curricula and educational experiences that provide all students with a holistic and integrative education.

The Framework

The IPFW faculty has identified six foundations of baccalaureate education.

#### Acquisition of Knowledge

Students will demonstrate breadth of knowledge across disciplines and depth of knowledge in their chosen discipline. In order to do so, students must demonstrate the requisite information-seeking skills and technological competencies.

#### Application of Knowledge

Students will demonstrate the ability to integrate and apply that knowledge, and, in so doing, demonstrate the skills necessary for life-long learning.

#### Personal and Professional Values

Students will demonstrate the highest levels of personal integrity and professional ethics.

#### A Sense of Community

Students will demonstrate the knowledge and skills necessary to be productive and responsible citizens and leaders in local, regional, national, and international communities. In so doing, students will demonstrate a commitment to free and open inquiry and mutual respect across multiple cultures and perspectives.

#### Critical Thinking and Problem Solving

Students will demonstrate facility and adaptability in their approach to problem solving. In so doing, students will demonstrate critical-thinking abilities and familiarity with quantitative and qualitative reasoning.

#### Communication

Students will demonstrate the written, oral, and multimedia skills necessary to communicate effectively in diverse settings.

These foundations provide the framework for all baccalaureate degree programs. The foundations are interdependent, with each one contributing to the integrative and holistic education offered at IPFW.

*Approved by the [IPFW Faculty Senate](#) April 10, 2006*

**IPFW BACCALAUREATE FRAMEWORK AND THE BACHELOR OF SCIENCE IN MEDICAL IMAGING**

Course Number	Course Name	Acquisition of Knowledge	Application of Knowledge	Personal and Professional Values	A Sense of Community	Critical Thinking and Problem Solving	Communication
ENG W131	Elementary Composition	X	X			X	X
MA 15300	Algebra and Trigonometry I	X	X			X	
COM 11400	Fundamentals of Speech Communication	X	X	X	X		X
CHM 10400	Living Chemistry	X	X			X	
BIOL 20300	Human Anatomy and Physiology	X	X		X	X	X
BIOL 20400	Human Anatomy and Physiology	X	X		X	X	
PHYS 22300	X-ray Physics	X	X			X	
PSY 102000 or SOC S161	Elementary Psychology Principles of Sociology	X	X	X	X		
NUR 10600	Medical Terminology	X	X		X	X	X
STAT 12500	Communicating with Statistics	X	X			X	X
PHIL 11100 or PHIL 31200	Ethics Medical Ethics	X	X	X	X	X	
RADX R105	Orientation to Radiography	X	X	X	X	X	X
RADX R111	Radiography I with Lab	X	X	X	X	X	X
RADX-R106	Fundamentals of Patient Care	X	X	X	X	X	X
RADX R270	Radiologic Physics	X	X			X	
RADX R211	Radiography II with Lab	X	X	X	X	X	X
RADX R271	Foundations of Image Acquisition	X	X			X	
RADX-R304	Cross Sectional Anatomy	X	X			X	
RADX R215	Medical Imaging Modalities	X	X	X	X	X	X
RADX R255	Radiation Biology	X	X			X	
RADX R305	Radiographic Image Critique	X	X	X	X	X	X
RADX R206	Advanced Patient Care	X	X	X	X	X	X
RADX R306	Radiographic Pathology	X	X			X	

**IPFW BACCALAUREATE FRAMEWORK AND THE BACHELOR OF SCIENCE IN MEDICAL IMAGING**

Course Number	Course Name	Acquisition of Knowledge	Application of Knowledge	Personal and Professional Values	A Sense of Community	Critical Thinking and Problem Solving	Communication
RADX R310	Seminar in Radiography	X	X	X	X	X	X
RADX R371	Advanced Image Acquisition	X	X			X	
RADX R401	Legal Issues in Imaging	X	X	X	X	X	X
RADX R410	PACS/RIS	X	X	X		X	
RADX R450	Quality Management	X	X	X	X	X	X
RADX R451	Principles of CT	X	X	X			
RADX R320	Professional Development	X	X	X	X	X	X
RADX R400	Leadership in Medical Imaging	X	X	X	X	X	X
RADX R481	Capstone	X	X	X	X	X	X
RADX R190	Introduction to Clinical Education	X	X	X	X	X	X
RADX R191	Clinical Education I	X	X	X	X	X	X
RADX R192	Clinical Education II	X	X	X	X	X	X
RADX R291	Clinical Education III	X	X	X	X	X	X
RADX R292	Clinical Education IV	X	X	X	X	X	X
RADX R293	Clinical Education V	X	X	X	X	X	X
RADX R391	Clinical Education VI	X	X	X	X	X	X

Senate Document SD12-14  
(Amended & Approved, 4/1/2013)

TO: Fort Wayne Senate

FROM: Educational Policy Committee  
Anne Argast, Chair

DATE: March 8, 2013

SUBJ: Change in General Education Program  
**EFFECTIVE FALL 2013**

DISPOSITION: To the presiding officer for implementation

WHEREAS, general education is centrally important to an undergraduate education,

WHEREAS, IPFW has been a state-wide leader in developing its general education program,

WHEREAS, the current general education program contains unique components including the area V (creative and Artistic Expression) and area VI (Inquiry and Analysis) requirements,

WHEREAS, the Indiana General Assembly with Senate Enrolled Act 182 has established a requirement for a Statewide Transfer General Education Core of at least 30 credit hours for all students seeking Associate and Bachelor degrees,

WHEREAS, the Indiana Commission of Higher Education with reference document 12/12/12 has published guidelines involving two categories, six areas, 41 learning outcomes and other specifications that state universities must incorporate into their core to be in compliance with SE 182,

WHEREAS, SE 182 and ICHE 12/12/12 require changes be made in our general education program,

WHEREAS, these changes to the program must be implemented by May 15, 2013,

BE IT RESOLVED, that the Senate approve the attached document which amends Senate Document 99-25 to incorporate the state mandated changes and make other changes to improve upon and preserve the unique qualities of the IPFW general education program.



Senate Document SD 99-25  
Supersedes SD 93-14 and SD 94-4  
(Supersedes SD 93-14 and SD 94-4)  
(Amended & Approved, 4/24/2000)  
(Amended & Approved, 2/12/2007)  
(Amended & Approved, 4/1/2013)

## **The Principles of General Education at IPFW**

### **EFFECTIVE FALL 2013**

General Education ensures students will be familiar with the important modes of human thought that are the foundations of science, philosophy, art and social behavior. General Education helps students understand the traditions that have informed one's own and other cultures of the world. It requires that students consider the nature and diversity of individuals, cultures and societies around the world, and gain appreciation of the natural systems in which these individuals, cultures and societies exist.

General Education at IPFW defines an integrated pedagogical framework that offers both substantive knowledge and an appreciation of multiple methods of inquiry and learning. Individual courses satisfy specific learning outcomes. The overall goals of the General Education program are achieved through cumulative course work. Individual courses should provide a basis for life-long learning, allow students to gain both substantive knowledge and an appreciation of method, and be appropriate for non-majors and for students who are unlikely to take another course in the discipline. This requirement does not preclude the possibility that the course might also be appropriate for majors.

Students who complete the General Education requirements at IPFW are expected to:

Read, write, and speak with comprehension, clarity, and precision in appropriate media.

Reason quantitatively.

Identify substantive knowledge and disciplinary methods and critically evaluate ideas.

Demonstrate an ability to use information literacy skills.

Demonstrate an ability to think critically and solve problems.

Understand the traditions that form one's own and other cultures.

Be familiar with modes of human thought that are the foundations of science, philosophy, art and social behavior.

Understand aspects of the natural world.

Use acquired knowledge and skills to create new scholarship.

## **Categorical Framework**

The Statewide Transfer General Education Core for associate and bachelor degree programs at IPFW shall consist of 30 credits, distributed as indicated, in areas 1-3 of category A, areas 4-7 of category B, and all the enumerated competencies 1.1-6.7 or 1.1-7.4, as defined later in this document with specific exemptions as noted.

All students completing a bachelor degree program at IPFW must also complete category C: Capstone.

A student who completes requirements in categories A and B shall have completed the Statewide Transfer General Education Core, and this achievement shall be noted on the student's transcript. A student transferring to IPFW with a similar notation from another college or university shall be exempt from additional requirements in categories A and B.

### *A. Foundational Intellectual Skills*

1. Written Communication (at least 3 cr and all outcomes in approved courses)
2. Speaking and Listening (at least 3 cr and all outcomes in approved courses)
3. Quantitative Reasoning (at least 3 cr and all outcomes in approved courses)

### *B. Ways of Knowing*

4. Scientific Ways of Knowing (at least 3 cr and all outcomes in approved courses)
5. Social and Behavioral Ways of Knowing (at least 3 cr and all outcomes in approved courses)
6. Humanistic and Artistic Ways of Knowing (at least 3 cr and all outcomes in approved courses)
7. Interdisciplinary or Creative Ways of Knowing (at least 3 cr and all outcomes in approved course)

The remaining 9 credit hours of the state-mandated general education should be taken by students from among the approved courses in Categories A and B as needed to fulfill their remaining state-mandated outcomes and as works best for their programs/majors.

### *C. Capstone*

8. Capstone Experience (at least 3 cr and all outcomes in an approved course)

## ***Learning Outcomes for Categories A and B***

### **Category A: Foundational Intellectual Skills**

Linguistic and numerical foundations are requisite to thinking and communicating critically and creatively. Foundational skills help students to speak and write precisely, clearly, and persuasively; read and listen actively and with comprehension; and reason quantitatively as a means of drawing reliable conclusions. These skills are fundamental, and courses in category A are best completed in each student's first 30 credits of enrollment.

#### **1. Written Communication**

*Upon completion of the Written Communication competency, students will be able to:*

- 1.1. Produce texts that use appropriate formats, genre conventions, and documentation styles while controlling tone, syntax, grammar, and spelling.
- 1.2. Demonstrate an understanding of writing as a social process that includes multiple drafts, collaboration, and reflection.
- 1.3. Read critically, summarize, apply, analyze, and synthesize information and concepts in written and visual texts as the basis for developing original ideas and claims.
- 1.4. Demonstrate an understanding of writing assignments as a series of tasks including identifying and evaluating useful and reliable outside sources.
- 1.5. Develop, assert and support a focused thesis with appropriate reasoning and adequate evidence.
- 1.6. Compose texts that exhibit appropriate rhetorical choices, which include attention to audience, purpose, context, genre, and convention.
- 1.7. Demonstrate proficiency in reading, evaluating, analyzing, and using material collected from electronic sources (such as visual, electronic, library databases, Internet sources, other official databases, federal government databases, reputable blogs, wikis, etc.).

## **2. Speaking and Listening**

*Upon completion of the Speaking and Listening competency, students will be able to:*

- 2.1. Use appropriate organization or logical sequencing to deliver an oral message.
- 2.2. Adapt an oral message for diverse audiences, contexts, and communication channels.
- 2.3. Identify and demonstrate appropriate oral and nonverbal communication practices.
- 2.4. Advance an oral argument using logical reasoning.
- 2.5. Provide credible and relevant evidence to support an oral argument.
- 2.6. Demonstrate the ethical responsibilities of sending and receiving oral messages.
- 2.7. Summarize or paraphrase an oral message to demonstrate comprehension.

## **3. Quantitative Reasoning**

*Upon completion of the Quantitative Reasoning competency, students will be able to:*

- 3.1. Interpret information that has been presented in mathematical form (e.g. with functions, equations, graphs, diagrams, tables, words, geometric figures).
- 3.2. Represent information/data in mathematical form as appropriate (e.g. with functions, equations, graphs, diagrams, tables, words, geometric figures).
- 3.3. Demonstrate skill in carrying out mathematical (e.g. algebraic, geometric, logical, statistical) procedures flexibly, accurately, and efficiently to solve problems.
- 3.4. Analyze mathematical arguments, determining whether stated conclusions can be inferred.
- 3.5. Communicate which assumptions have been made in the solution process.
- 3.6. Analyze mathematical results in order to determine the reasonableness of the solution.
- 3.7. Cite the limitations of the process where applicable.
- 3.8. Clearly explain the representation, solution, and interpretation of the math problem.

## Category B: Ways of Knowing

### **4. Scientific Ways of Knowing**

Natural science is a knowledge domain transcending the human experience. Students should understand the role of observation and inference in investigations; how natural science theories are formed, tested, and validated; the limitations inherent to natural scientific inquiry; and the impact of science and mathematics upon intellectual history. Courses in this way of knowing foster scientific thinking; knowledge of the physical and natural world; and relativizes humanity's position within the universe.

*Upon completion of the Scientific competency, students will be able to:*

- 4.1. Explain how scientific explanations are formulated, tested, and modified or validated.
- 4.2 Distinguish between scientific and non-scientific evidence and explanations.
- 4.3 Apply foundational knowledge and discipline-specific concepts to address issues or solve problems.
- 4.4 Apply basic observational, quantitative, or technological methods to gather data and generate evidence-based conclusions.
- 4.5 Use current models and theories to describe, explain, or predict natural phenomena.
- 4.6 Locate reliable sources of scientific evidence to construct arguments related to real-world issues.

### **5. Social and Behavioral Ways of Knowing**

Students must understand the nature and diversity of individuals, cultures and societies around the world. An exploration of behavioral, societal and cultural processes utilizing the application of scientific methodologies forms the basis for that understanding. This understanding of diverse systems assists the student in overcoming provincialism; in developing the willingness, confidence, and sense of responsibility for making informed decisions; and in acquiring the ability to assess personal behavior and that of others. Such learning requires an historical consciousness; familiarity with components of social structure and social institutions; knowledge of basic behavioral processes; comprehension of the interplay among ideas, technology, and social organization; and appreciation of the complex dimensions of personal and institutional rules.

*Upon completion of the Social and Behavioral competency, students will be able to:*

- 5.1 Demonstrate knowledge of major concepts, theoretical perspectives, empirical patterns, or historical contexts within a given social or behavioral domain.
- 5.2 Identify the strengths and weaknesses of contending explanations or interpretations for social, behavioral, or historical phenomena.
- 5.3 Demonstrate basic literacy in social, behavioral, or historical research methods and analyses.
- 5.4 Evaluate evidence supporting conclusions about the behavior of individuals, groups, institutions, or organizations.
- 5.5 Recognize the extent and impact of diversity among individuals, cultures, or societies in contemporary or historical contexts.
- 5.6 Identify examples of how social, behavioral, or historical knowledge informs and can shape personal, ethical, civic, or global decisions and responsibilities.

## **6. Humanistic and Artistic Ways of Knowing**

Humanistic thought is the attempt to resolve such abiding issues as the meaning of life, the role of the arts in our understanding of what it is to be human, and the limits of knowledge.

Humanistic inquiry assesses-across temporal, cultural, disciplinary, and theoretical divisions-how humans view themselves in relation to other humans, to nature, and to the divine. Studies in the humanities offer students the intellectual resources to develop mature self-concepts and heightened social consciousness.

*Upon completion of the Humanistic and Artistic competency, students will be able to:*

- 6.1 Recognize and describe humanistic, historical, or artistic works or problems and patterns of the human experience.
- 6.2 Apply disciplinary methodologies, epistemologies, and traditions of the humanities and the arts, including the ability to distinguish primary and secondary sources.
- 6.3 Analyze and evaluate texts, objects, events, or ideas in their cultural, intellectual or historical contexts.
- 6.4 Analyze the concepts and principles of various types of humanistic or artistic expression.
- 6.5 Create, interpret, or reinterpret artistic and/or humanistic works through performance or criticism.
- 6.6 Develop arguments about forms of human agency or expression grounded in rational analysis and in an understanding of and respect for spatial, temporal, and cultural contexts.
- 6.7 Analyze diverse narratives and evidence in order to explore the complexity of human experience across space and time.

## **7. Interdisciplinary or Creative Ways of Knowing**

True scholarship necessarily involves the creation of a deeper understanding about nature and/or the human experience. This understanding is sometimes achieved through a traditional academic approach and sometimes through performance and art. Scholarship cannot always be compartmentalized into a single way of knowing, and performance is inherently based upon a broad experience of life and the world around us.

A student will complete a broadly interdisciplinary course, *or* will complete a course having a significant experiential, integrative and/or creative performance.

*Option 1: Upon completion of the Interdisciplinary Ways of Knowing using a broadly interdisciplinary course, students will be able to:*

Meet any three learning outcomes from 1.1 to 3.8 of the Category A foundation areas and any two outcomes from each of two different areas selected from areas 4-6 under Category B: Ways of Knowing.

*Option 2: Upon completion of the Interdisciplinary Ways of Knowing using an experiential, integrative and/or creative performance, students will be able to:*

7.1 Demonstrate an understanding of the creative process using the vocabulary of the appropriate discipline.

7.2 Perform or create a work of personal expression and bring the work to fruition using applicable skills.

7.3 Articulate a reflective and critical evaluation of their own and other's creative efforts using written and/or oral communication.

7.4 At least two additional learning outcomes selected from 1.1-6.7.

## Criteria for Including a Course in a Specific Area of Categories A and B

In its content and its approach, a course should satisfy the goals and criteria of the general-education area to which it belongs.

Courses approved for general education in:

*Category A, Foundational Intellectual Skills, areas 1-3*; must satisfy a minimum of 2/3 of the learning outcomes in the area to which it is assigned.

*Category B, Ways of Knowing, areas 4-6*; must satisfy a minimum of 2/3 of the learning outcomes in the area to which it is assigned, and must include at least one outcome from foundational areas 1, 2 or 3. No more than 10 learning outcomes may be declared for any single course.

*Category B, Ways of Knowing, area 7*; must be broadly interdisciplinary and meet any three learning outcomes from 1.1 to 3.8 Category A foundation areas and any two outcomes from each of the two different areas from areas 4-6 under Category B: Ways of Knowing *or* be centered on an experiential, integrative and/or creative performance and satisfy learning outcomes 7.1-7.4.

### *Exemptions and Affirmations*

- a) A general education course may satisfy learning outcomes outside the assigned area. All general education courses should help students advance their understanding and mastery of Foundational Skills and should help prepare students for successful learning in the Capstone. It is understood that not all foundation skills will be addressed equally in any given course.
- b) Courses in category A should not have college-level prerequisites. Courses in category B should not require college-level prerequisites except courses taken as part of the Foundational Intellectual Skills core.
- c) An approved general education course should be at least a 3 credit course.
- d) A student must earn a grade of 'C-' or better in each course used to satisfy the IPFW general education requirements.
- e) Students who place above the level of a general-education course in Area A may satisfy the requirement by completing a higher-level course in the same area. Upon satisfactory completion of this higher-level course the student's record will be marked as having completed the area and the associated learning outcomes.
- f) Up to 6 credits of approved general education courses satisfying requirements in areas A and B, and 3 credits satisfying requirements in area C, may originate in the major.



- g) Departments/programs may replace up to six (6) credits of the required 30 credits in approved general-education courses in area B by more advanced courses when the following criteria are met: 1) the replacement courses are specifically required by the major, and 2) they meet the area definition, but are more advanced than courses approved for general education. Programs wishing to exercise this option should provide the General Education Subcommittee with a list of the proposed replacement courses for the specified area(s) and a brief statement of the rationale. A student who completes the higher-level course will be given credit for the learning outcomes associated with the lower-level course it replaces.
- h) Students transferring from another university and who have not completed the entire core may still transfer general education course credit to IPFW. This credit may have originated on-campus, through distance education, or through dual-credit in the high schools. If this credit is considered equivalent to the content of an approved general education course it may count towards the credit hour requirement in the area but cannot be used to satisfy the associated learning outcomes unless the course was originally and specifically designed to meet learning outcomes in the Statewide Transfer General Education Core at the originating institution. In this case the student will be given credit for all the learning outcomes in the course as defined at IPFW.
- i) Dual-credit courses certified by IPFW must meet the same learning outcomes as the courses originating on or from the IPFW campus.
- j) Because the new general education program was designed to be more flexible, one of the possible results will be a variation between the recommended ways in which students can meet their general education requirements from major to major. All general education “paths” should be transferrable from school to school/program to program/department to department, i.e. students switching majors should not be required to redo their general education requirements.

### **Category C: Capstone**

In addition to the 30 credit transfer core, all IPFW Bachelor's Degree candidates are expected to complete an approved three credit capstone course at the 300 level or higher. The Capstone course reflects the faculty commitment to the acquisition and application of knowledge as fundamental to the baccalaureate degree, and allows flexibility and innovation in Capstone course creation.

All capstone projects will involve the acquisition or application of knowledge. This should be broadly construed and may include the exploration of any discipline-specific scholarship including the scholarly activities typically associated with the professional schools, service professions, engineering and the performing arts. A capstone may center on any aspect of university life as long as its primary focus is on the acquisition or application of knowledge. The project may involve a formal service learning experience, or a formal international study experience as its primary focus.

All capstone projects, including those in the performing arts, shall produce a significant product in a discipline-appropriate format, demonstrating the scholarly methods, techniques and conventions associated with the discipline.

*Upon completion of the Capstone, students will be able to:*

- 8.1. Produce an original work involving the creation or application of knowledge, performance or service.
- 8.2. Report the results of original work through a discipline-appropriate product.
- 8.3. Demonstrate a high level of personal integrity and professional ethics by understanding the ethical responsibilities related to the profession associated with the subject of the capstone project.
- 8.4. Demonstrate critical-thinking abilities and familiarity with quantitative and/or qualitative reasoning.

## **Implementation of the General Education Program**

Responsibility for administering the General Education program resides with the Chief Academic Officer and the General Education Subcommittee. The General Education Subcommittee reports to the Faculty through the Educational Policy Committee, as specified by the Senate Bylaws.

1. Proposals for new courses in the General Education program shall be submitted to the Chief Academic Officer (or designee). Immediately upon receipt, the proposal shall be circulated for comment and remonstrance by the faculty, and given to the General Education Subcommittee for action. Within sixty (regular academic session) days the subcommittee shall either approve or reject the proposal. If rejected, the General Education Subcommittee shall return the proposal to the originating department with specific reasons and suggestions to make the proposed course acceptable within the general education program
2. The General Education Subcommittee shall conduct an on-going assessment of the courses in the general education curriculum.
3. The Chief Academic Officer (or designee) shall make available to all faculty the procedures used for course certification, decertification, and assessment.
4. The Chief Academic Officer (or designee) shall publish a list of approved courses in each of the six state-mandated competency areas, area 7, and IPFW capstone area 8.
5. The Chief Academic Officer (or designee) shall publish a list of approved courses covering one or more of the 41 state-mandated outcomes.
6. The Chief Academic Officer (or designee) shall publish a public report describing how IPFW assures student mastery of the student learning outcomes.

### Bachelor of Science Medical Imaging General Education Course List

All students enrolled in the program will be required to complete the following general education courses:

<b>GENERAL EDUCATION</b>		<b>TOTAL HOURS 33</b>
<b>CATEGORY A1</b>	<b>Written Communication</b>	<b>3 Credit Hours</b>
ENG W131	Elementary Composition	3 Cr
<b>CATEGORY A2</b>	<b>Speaking and Listening</b>	<b>3 Credit Hours</b>
COM 11400	Fundamentals of Speech	3 Cr
<b>CATEGORY A3</b>	<b>Quantitative Reasoning</b>	<b>6 Credit Hours</b>
MA 15300	Algebra and Trigonometry I	3 Cr
STAT 12500	Communicating with Statistics	3 Cr
<b>CATEGORY B4</b>	<b>Scientific Ways of Knowing</b>	<b>6 Credit Hours</b>
CHM 10400	Living Chemistry	3 Cr
PHYS 22300	X-ray Physics	3 Cr
<b>CATEGORY B5</b>	<b>Social Behavioral Ways of Knowing</b>	<b>3 Credit Hours</b>
PSY 12000	Elementary Psychology <i>or</i>	3 Cr
SOC S161	Principles of Sociology	
<b>CATEGORY B6</b>	<b>Humanistic &amp; Artistic Ways of Knowing</b>	<b>3 Credit Hours</b>
PHIL 31200	Medical Ethics <i>or</i>	3 Cr
PHIL 11100	Ethics	
<b>CATEGORY B7</b>	<b>Interdisciplinary Ways of Knowing</b>	<b>3 Credit Hours</b>
Elective	Any B7 General Education approved course	3 Cr
<b>CATEGORY C8</b>	<b>Capstone Experience</b>	<b>3 Credit Hours</b>
RADX R481	Internship / Capstone	3 Cr
<b>ELECTIVE GENERAL EDUCATION COURSE</b>		<b>3 Credit Hours</b>
Elective	Any General Education approved course	3 Cr

Program Number 4767Program Name BSMI - Indiana University-Purdue University Fort WayneDate 07/26/2013

## Radiography Curriculum Analysis

**DIRECTIONS:** Determine the course(s) in which each of the following content area is covered and enter the course number(s) and/or title(s). For guidance in what should be covered for each content area, please refer to the Radiography Curriculum (2012) published by the American Society of Radiologic Technologists.

Professional Curriculum	Program Course(s)
<b>Clinical Practice</b>	
Clinical Practice	<b>R190, R191, R192, R291, R292, R293, 391</b>
Procedural Performance	<b>R190, R191, R192, R291, R292, R293, 391</b>
Clinical Competency	<b>R190, R191, R192, R291, R292, R293, 391</b>
<b>Digital Image Acquisition and Display</b>	
Basic Principles of Digital Radiography	<b>R271, R305, R371, R410</b>
Image Acquisition	<b>R271, R305, R371, R410</b>
Image Acquisition Errors	<b>R271, R305, R371, R410, R450</b>
Fundamental Principles of Exposure	<b>R105, R111, R270, R271, R371</b>
Image Evaluation	<b>R111, R305, R371, R410, R450</b>
Quality Assurance and Maintenance Issues	<b>R270, R271, R371, R410, R450</b>
Display	<b>R111, R271, R305, R371, R410, R450</b>
Data Management	<b>R271, R371, R410</b>
<b>Ethics and Law in the Radiologic Sciences</b>	
Ethics and Ethical Behavior	<b>R190, R191, R320, R401, R400, PHIL 111 or PHIL 312</b>
Ethical Issues in Health Care	<b>R190, R191, R105, R320, R401</b>
Legal Issues	<b>R401</b>
Legal Doctrines	<b>R401</b>
Patient Consent	<b>R106, R206, R211</b>

<b>Professional Curriculum</b>	<b>Program Course(s)</b>
<b>Human Structure and Function</b>	
Anatomical Nomenclature	R111, BIOL 203, BIOL204, NUR106, R304
Chemical Composition	BIOL 203, BIOL204
Cell Structure and Genetic Control	BIOL 203, BIOL204,R255
Metabolism	BIOL 203, BIOL204
Tissues	BIOL 203, BIOL204
Skeletal System	R111, BIOL 203, BIOL204
Muscular System	BIOL 203, BIOL204
Nervous System	BIOL 203, BIOL204,R304
Sensory System	BIOL 203, BIOL204
Endocrine System	BIOL 203, BIOL204
Digestive System	R111, BIOL 203, BIOL204, R211
Cardiovascular System	BIOL 203, BIOL204, R304
Lymphatic System and Immunity	BIOL 203, BIOL204
Respiratory System	R111, BIOL 203, BIOL204
Urinary System	R111, BIOL 203, BIOL204, R211, R304
Reproductive System	BIOL 203, BIOL204, R304
Introduction to Sectional Anatomy	BIOL 203, BIOL204, R304
<b>Image Analysis</b>	
Image Appearance Standards	<b>R305, R371, R450</b>
Imaging Standards	R305, R371, R450
Image Appearance Characteristics	R305, R111, R271, R371, R410, R450
Procedural Factors	R305, R111
Corrective Actions	R305, R371, R410, R450
<b>Imaging Equipment</b>	
X-ray Circuit	<b>R270, R271, R450</b>
Radiographic Equipment	R105, R111, R270, R271, R371, R450
Diagnostic X-ray Tubes	R111, R270, R271, R371, R450
Image Intensified Fluoroscopy	R270, R371, R450
Quality Control	R270, R271, R371, R450
Modality Exploration and Radiation Therapy	R215, R320

<b>Professional Curriculum</b>	<b>Program Course(s)</b>
<b>Introduction to Computed Tomography</b>	
Components, Operations, and Processes	R215, R451
Radiation Protection	R215, R255, R451
<b>Introduction to Radiologic Science and Health Care</b>	
The Health Science Professions	R106,R105
The Health Care Environment	R106, R320, R400
Quality Management	R270, R371, R400, R450
Hospital Organization	R106, R105, R320, R400
Radiology Organization	R105, R320, R400
Accreditation	R106,R105, R400
Regulatory Agencies	R190, R106,R105, R255, R450
Professional Credentialing	R105, R320
Professional Organizations	R105, R320
Professional Development and Advancement	R105, R320, R400, R481
<b>Medical Terminology</b>	
The Word-Building Process	R111, NUR106
Medical Abbreviations and Symbols	R111, NUR106
Radiologic Technology Procedures and Terminology	R111, NUR106
Understanding Orders, Requests, and Diagnostic Reports	R111, NUR106, R106, R206
<b>Patient Care in Radiologic Sciences</b>	
Health Care Team	R190, R106, R206, R400
Professionalism and Communication in Patient Care	R111, R190, R106, R206, R211, R320, R400
Patient/Radiographer Interactions	R111, R190, R106, R206
Safety and Transfer Positioning	R106, R206
Evaluating Physical Needs	R106, R206
Infection Control	R106, R206
Medical Emergencies	R106, R206
Trauma	R106, R206, R451
Contrast Studies	R106, R206, R211, R451
Reactions to Contrast Agents	R106, R206, R211
Tubes, Catheters, Lines, and Other Devices	R106, R206
Mobile and Surgical Radiography	R106, R206, R211

<b>Professional Curriculum</b>	<b>Program Course(s)</b>
<b>Pharmacology and Venipuncture</b>	
Drug Nomenclature	R206
Methods of Drug Classification	R206
General Pharmacologic Principles	R206
Six Rights of Drug Safety	R106, R206
Drug Categories of Relevance to Radiography (Uses and Impacts on Patient)	R206
Contrast Agents	R106, R206, R211, R451
Routes of Drug Administration	R206
Venipuncture	R206
Current Practice Status	R206
<b>Principles of Imaging</b>	
Exposure Factors	R111, R270, R271, R371
Brightness Digital Display/Density (Film)	R305, R270, R271, R371
Contrast	R305, R270, R271, R371
Recorded Detail/Spatial Resolution	R305 R270, R271, R371
Distortion	R305 R271, R371
Exposure Latitude	R305, R271, R371
Beam-Limiting Devices	R111, R305, R270, R271, R371
Beam Filtration	R111, R305, R270, R271, R371
Scattered and Secondary Radiation	R111, R305, R270, R271, R371
Grids	R111, R270, R271, R371
Exposure Factor Formulation	R111, R270, R271, R371
<b>Radiation Biology</b>	
Introduction	
Molecule	R255,R105
Basic cellular biology	R255,R105
Types of ionizing radiation	R255,R105
Radiation Energy Transfer	R255
Radiation Effects	R255,R105
Radiosensitivity and Response	R255
<b>Radiation Production and Characteristics</b>	
Structure of the Atom	R270, R271, R371,R255
Nature of Radiation	R270, R271, R371
X-ray Production	R111, R270, R271, R371
Interactions of Photons with Matter	R111, R270, R271, R371,R255



<b>Professional Curriculum</b>	<b>Program Course(s)</b>
<b>Radiation Protection</b>	
Introduction	
Justification for radiation protection	R111, R105, R255, R270
Potential biological damage of ionizing radiation	R105, R255
Objectives of a radiation protection program	R105, R255
Sources of radiation	R105, R255, R270
Legal and ethical responsibilities	R105, R255, R401
Units, Detection, and Measurement	R105, R255, R270
Surveys, Regulatory/Advisory Agencies and Regulations	R255
Personnel Monitoring	R105, R255
Application	R255
Patient Protection	R111, R105, R255
<b>Radiographic Pathology</b>	
Definitions/Terminology	R306, R304
Classifications (Definition, Examples, Sites, Complications, Prognosis)	R306
Causes of Disease (Process, Examples)	R306
Radiologic Pathology (Definitions, Etiology, Examples, Sites, Complications, Prognosis, Radiographic Appearance, Procedural and Technique Considerations, Appropriate Imaging Modality)	R306, R451
<b>Radiographic Procedures</b>	
Standard Terminology for Positioning and Projection	R111, R305, R211
General Considerations	R111, R211
Patient Considerations	R111, R305, R211
Positioning Considerations for Routine Radiographic Procedures	R111, R305, R211
Procedural Considerations for Contrast Studies	R305, R211, R206
Additional Imaging Modalities and Radiation Therapy	R215

Educational programs in radiography are **required** to incorporate mathematical/logical reasoning and written/oral communication as general education elements in their curricula. There must be a minimum of 15 credit hours of general education coursework. Each program is required to submit information regarding the courses

<b>Required Post-secondary General Education</b>	<b>Credit Hour</b>	<b>Course Number</b>	<b>Course Title</b>
Mathematical/Logical Reasoning (required)	<b>6</b>	<b>MA 15300 STAT 12500</b>	<b>College Algebra &amp; Trigonometry Communicating with Statistics</b>
Written/Oral Communication (required)	6	ENG W131 COMM 11400	English Composition Fundamentals of Speech Communication
Total Hours for Required Post-secondary General Education	12		

In the spaces below, list the additional post-secondary general education coursework students are required to complete that meets/exceeds the 15 hours

<b>Category (See Below)</b>	<b>Course Number</b>	<b>Course Title</b>	<b>Credit Hours</b>
Natural Science	CHM 10400	Living Chemistry	3
Natural Science	PHYS 22300	X-ray Physics	3
Arts & Humanities	PHIL 11100 or PHIL 31200	Ethics or Medical Ethics	3
Social and Behavioral	PSY 12000 or SOC S161	Introduction to Psychology or Principles of Sociology	3
Interdisciplinary Elective	Elective	Elective	3
Gen Ed Elective	Elective	Elective	3
<b>Total Hours for Additional Post-secondary General Education Courses</b>			<b>18</b>

Categories:

- Mathematical/logical reasoning
- Written/oral communication

- Arts and humanities
- Information systems
- Social/behavioral sciences
- Natural sciences

# Radiography Curriculum

*Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3909.*

*Radiography Curriculum was produced by the ASRT Radiography Curriculum Revision Project Group.*

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# Introduction

The first ASRT Radiography Curriculum was written in 1952. Throughout its history, the goal of this document has been to outline a common body of knowledge that is essential for entry-level radiographers. The challenge in any curriculum is to give students a solid foundation of traditional core knowledge while also providing opportunities to develop skills that will serve them beyond entry to the radiologic science profession. In particular, students must develop skills in areas such as information literacy, scientific inquiry, self-reflection, collaboration and mentoring.

The guidance provided by this curriculum document will span the time period prior to and after the projected Jan. 1, 2015 start date of the American Registry of Radiologic Technology's minimum associate degree requirement for candidates seeking professional certification. The focus of this document is on the pre-professional core instructional content that will be expanded with institution-specific course content to fulfill metrics for receipt of an academic degree. It is beyond the scope of this document to outline administrative strategies for programs that are unable to award graduates an academic degree to comply with the ARRT 2015 degree requirement.

Postsecondary general education content is included as a "required" element of this radiography curriculum. General education provides an opportunity for personal enrichment and exploration outside the confines of the technical professional curriculum. The general education content objectives in this curriculum were purposely labeled "global content objectives" to give program officials flexibility in determining specific credit-bearing course work that will satisfy these objectives. Following 2015, it is expected that this component of the entry-level curriculum will be satisfied with general education courses needed to fulfill institution-specific degree requirements.

This curriculum is designed to ensure that entry-level radiographers possess the technical skills outlined in the ASRT Radiography Practice Standards. In addition, the graduate will exhibit the following professional characteristics:

- Prudent judgment in administering ionizing radiation to produce diagnostic images.
- A focus on providing optimum patient care in a society that is becoming increasingly diverse and experiencing generational, cultural and ethnic shifts.
- The ability to work with others in a team relationship.
- An understanding of the intricacies associated with providing direct patient care in today's health care setting.
- The skill to use modern technologies to research and retrieve information, weigh and discriminate between good and poor sources of information, and take action based upon the acquisition of new information and knowledge.
- Stewardship over the security and confidentiality associated with patient medical information.

- Skills that promote career-long learning, where the radiographer assumes the role of student and that of teacher.
- An eagerness to collaborate with others in the medical imaging community to promote standards of excellence in the medical imaging sciences.
- A willingness to contribute to the education and clinical skills development of radiologic science students.

The document itself is divided into specific content areas: pre-professional core and optional content.

- Pre-professional core content: This content makes up the body of the document and reflects educational content the professional community supports as essential for preparation to enter the radiography field. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.
- Optional content: This section is intended to decrease the hardship imposed on programs by requiring instructional content that is representative of technologies and technical principles that have been replaced with newer technical systems. It is recognized that traditional technologies are still part of the fabric of many communities. Content in this section will assist program planners wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of a given program or local employment market.

A list of learning objectives and appendices indexed by content area has been incorporated into this document to serve as a resource for program planners and course managers. Faculty members also are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula.

Radiography programs are encouraged to organize the content and objectives to meet their individual goals and needs. In particular, students must develop skills in areas such as information literacy, scientific inquiry, self-reflection, collaboration and mentoring. Advances in technology and employer expectations require more independent judgment by radiographers.

The ASRT Radiography Curriculum serves as a blueprint for educators to follow in designing their programs and in ensuring that their programs match the profession's standards. In the radiologic sciences, educators not only must teach the essential clinical skills that employers expect of graduates, but also must ensure that students will be prepared to take certification examinations offered by the ARRT. This curriculum allows for faculty flexibility to meet the needs of the local community, yet satisfy the requirements for accreditation standards and the ARRT examination. It also offers a foundation for a transition to baccalaureate studies and, more importantly, for individual lifelong learning.

# Radiography Curriculum

## Table of Contents

Clinical Practice .....	1
Digital Image Acquisition and Display.....	4
Ethics and Law in the Radiologic Sciences .....	9
Human Structure and Function .....	11
Image Analysis.....	19
Imaging Equipment.....	22
Introduction to Computed Tomography .....	26
Introduction to Radiologic Science and Health Care.....	28
Medical Terminology.....	32
Patient Care in Radiologic Sciences .....	34
Pharmacology and Venipuncture.....	44
Principles of Imaging.....	49
Radiation Biology .....	53
Radiation Production and Characteristics.....	57
Radiation Protection.....	60
Radiographic Pathology.....	65
Radiographic Procedures .....	67
Required General Education .....	73
Learning Objectives .....	75
Clinical Practice .....	76
Digital Image Acquisition and Display.....	78
Ethics and Law in the Radiologic Sciences .....	79
Human Structure and Function .....	80
Image Analysis.....	82
Imaging Equipment.....	83
Introduction to Computed Tomography .....	84
Introduction to Radiologic Science and Health Care.....	85

Medical Terminology.....	86
Patient Care in Radiologic Sciences .....	87
Pharmacology and Venipuncture .....	89
Principles of Imaging.....	90
Radiation Biology .....	91
Radiation Production and Characteristics.....	92
Radiation Protection.....	93
Radiographic Pathology.....	95
Radiographic Procedures .....	96
Optional Content.....	97
Basic Principles of Computed Tomography .....	98
Film-Screen Image Acquisition and Processing .....	100
Imaging Equipment.....	103
Introduction to Forensic Radiography .....	104
Sectional Anatomy.....	106
Radiologic Science Resources .....	118



# Clinical Practice

## Description

Content and clinical practice experiences should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of radiologic procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient preparatory to, during and following the radiologic procedure.

## Content

### I. Clinical Practice

- A. Code of ethics/professional behavior
  - 1. Consistency, Accuracy, Responsibility and Excellence (CARE) in Medical Imaging and Radiation Therapy
  - 2. Incident reporting mechanisms
  - 3. Standards for supervision
    - a. Direct
    - b. Indirect
  - 4. The Patient Care Partnership: Understanding expectations, rights and responsibilities
- B. Professional communication
  - 1. Patients
  - 2. Patient's family
  - 3. Health care team
  - 4. Confidentiality of patient records (Health Insurance Portability and Accountability Act, or HIPAA, compliance)
- C. Radiographer Practice Standards
  - 1. Technical
  - 2. Professional
  - 3. Equipment operation
  - 4. Ability to adapt to varying clinical situations
  - 5. Emergency response
  - 6. Total quality management
- D. Values
  - 1. Personal
    - a. Values development
    - b. Effect on medical care

- c. Impact on patient care
    - d. Values clarification
  - 2. Societal
    - a. Rights and privileges
    - b. Community values
    - c. Impact on patient care
  - 3. Professional
    - a. Values development
    - b. Values conflict
    - c. Impact on patient care
- E. Culture, ethnicity and diversity
  - 1. Societal and individual factors
  - 2. Socioeconomic
  - 3. Gender
  - 4. Age
    - a. Infant
    - b. Child
    - c. Adolescent
    - d. Adult
    - e. Middle-aged
    - f. Geriatric
  - 5. Family structure and dynamics
  - 6. Geographical factors
  - 7. Religion
  - 8. Lifestyle choices and behaviors
  - 9. Sexual orientation
  - 10. Disability

## **II. Procedural Performance**

- A. Scheduling and sequencing of exams
- B. Order/requisition evaluation and corrective measures
- C. Facilities setup
- D. Patient assessment, clinical history, education and care
  - 1. Patient monitoring – emergency and nonemergency
    - a. Vital signs
    - b. Assessment and clinical history
    - c. Equipment
    - d. Patient emergencies
  - 2. Patient privacy and confidentiality
  - 3. Documentation and charting
  - 4. Infection control
  - 5. Patient education

- a. Communication style
- b. Age-specific
- c. Cultural and socioeconomic sensitivity
- d. Patient-focused care
- 6. Medical error reduction

E. Imaging

- 1. Positioning considerations
- 2. Technical considerations
- 3. Image acquisition
- 4. Image analysis

F. Radiation protection

- 1. Principles
- 2. Equipment and accessories

**III. Clinical Competency**

ARRT Competency Requirements (refer to the document located at [www.arrt.org/pdfs/Disciplines/Competency-Requirements/RAD-Competency-Requirements-2012.pdf](http://www.arrt.org/pdfs/Disciplines/Competency-Requirements/RAD-Competency-Requirements-2012.pdf)) \*

\*Refer to ARRT Competency Requirements for mandatory and elective requirements.

# Digital Image Acquisition and Display

## Description

Content imparts an understanding of the components, principles and operation of digital imaging systems found in diagnostic radiology. Factors that impact image acquisition, display, archiving and retrieval are discussed. Principles of digital system quality assurance and maintenance are presented.

**Special Note:** Digital imaging is a rapidly evolving technology. Every effort has been made to provide a curriculum outline that reflects, as accurately as possible, the state of the art of this discipline as of publication. Educators are encouraged to modify this outline with up-to-date information as it becomes available from vendors, clinical sites, textbooks, and technical representatives.

## Content

### I. Basic Principles of Digital Radiography

- A. Digital image characteristics
  - 1. Picture elements – pixels
  - 2. Pixel size
  - 3. Matrix size
  - 4. Spatial resolution
  - 5. Bit depth
  - 6. Contrast resolution
  
- B. Digital receptors
  - 1. Amorphous selenium/Thin film transistor (TFT) arrays
  - 2. Cesium iodide/amorphous silicon thin film transistor (TFT) arrays
  - 3. Charged coupled device (CCD) and complementary metal oxide semiconductor (CMOS) systems
  - 4. Photostimulable phosphor (PSP) plates
  
- C. Comparison of detector properties and evaluative criteria
  - 1. Detective quantum efficiency (DQE)
  - 2. Exposure index
  - 3. Spatial resolution
    - a. PSP
      - 1) Sampling frequency – pixel pitch
      - 2) Receptor size
      - 3) Light spread – phosphor layer thickness
    - b. TFT detector element (DEL) size
  
- D. Dynamic range and latitude
  - 1. Dynamic range of the detector
  - 2. Latitude – allowable error for optimal image acquisition
    - a. Exposure latitude

- b. Beam-part-receptor alignment latitude

## **II. Image Acquisition**

- A. Raw data acquisition
  - 1. Positioning
  - 2. Exposure field alignment and collimation
  - 3. Exposure – technique selection
  
- B. Image formation
  - 1. Image extraction
    - a. TFT, CMOS, CCD
    - b. PSP plate scanned by laser
  - 2. Digitized by analog-to-digital converter (ADC)
  - 3. Exposure field recognition
  - 4. Histogram created and analyzed by software
  - 5. Initial image processing
    - a. Exposure indicator determination
    - b. Automatic rescaling
    - c. Look-up table (LUT)
  - 6. Image enhancement processing
    - a. Gradient processing
      - 1) Brightness
      - 2) Contrast
    - b. Frequency processing
      - 1) Smoothing
      - 2) Edge enhancement
    - c. Equalization
  
- C. Exposure indicators
  - 1. Dose area product (DAP)
  - 2. Vendor-specific values
    - a. Relationship to patient exposure
    - b. Reader calibration
    - c. Centering and beam collimation
    - d. Optimal value ranges
  - 3. Exposure indicators

## **III. Image Acquisition Errors**

- A. Histogram analysis error
  - 1. Incorrect anatomic menu selection
  - 2. Exposure field recognition errors
    - a. Collimation border recognition
    - b. Exposure field distribution – multiple fields/plate
  - 3. Unexpected material in data set, e.g., metal
  - 4. Large overexposure error
  - 5. Inappropriate rescaling – dark or light image

- B. Low intensity radiation response – PSP only
  - 1. Background
    - a. Stores background exposure
      - 1) Plate responds to an exposure as low as 60  $\mu$ R
      - 2) Background is 40  $\mu$ R/day to 80  $\mu$ R/day
    - b. Plates unused for more than 48 hours should be erased
  - 2. Scatter no PSP storage in exam room
- C. Scatter control
  - 1. Beam limitation
  - 2. Optimal exposure
  - 3. Grid use
    - a. Kilovoltage peak (kVp)
    - b. Grid cutoff
    - c. Compare short dimension (SD) grid and long dimension (LD) grid
    - d. Storage

#### **IV. Fundamental Principles of Exposure**

- A. Optimal receptor exposure
  - 1. Milliampere-seconds (mAs)
  - 2. kVp
  - 3. Collimation
  - 4. Grid
  - 5. Source-to-image distance (SID)
  - 6. Speed class
  - 7. Fog
- B. Exposure myths and misconceptions associated with digital systems
- C. Control patient exposure
  - 1. Higher kVp levels
  - 2. Additional filtration
  - 3. Interfacing with automatic exposure control (AEC) systems
  - 4. As low as reasonably achievable (ALARA) principles
- D. Monitor patient exposure
  - 1. Part of quality assurance (QA) program
  - 2. Vendor-supplied software

#### **V. Image Evaluation**

- A. Evidence of appropriate exposure level (exposure indicator range)
  - 1. Exposure indicator range
  - 2. Noise
    - a. Computer noise
    - b. Electronic noise

- c. Material mottle
- d. Quantum mottle

B. Contrast

C. Recorded detail

D. Artifacts

- 1. Patient
- 2. Equipment
- 3. Exposure
- 4. Processing
- 5. Moiré effect

**VI. Quality Assurance and Maintenance Issues**

A. Technologist responsibilities

- 1. Image quality control
  - a. Exposure indicator appropriateness
  - b. Image accuracy
- 2. Plate maintenance
  - a. Cleaning and inspection
  - b. Erasure
- 3. Reject analysis

B. Service engineer or medical physicist responsibilities

**VII. Display**

A. Monitor

- 1. Plasma
- 2. Liquid crystal display (LCD)
- 3. Cathode ray tube (CRT)

B. Laser film

**VIII. Data Management**

A. Network

B. Hospital information system (HIS)

C. Radiology information system (RIS)

D. Picture archiving and communication system (PACS)

- 1. System components and functions
- 2. Emergency contingency plan
- 3. Digital imaging and communication in medicine (DICOM)
- 4. Teleradiography

5. Radiographer responsibilities
  - a. Access work order (worklist)
  - b. Postprocessing – image manipulation
  - c. Annotation issues
  - d. Transmitting images to PACS
  - e. HIPAA
  - f. Workflow

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# Ethics and Law in the Radiologic Sciences

## Description

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

## Content

### I. Ethics and Ethical Behavior

- A. Origins and history of medical ethics
- B. Moral reasoning
- C. Personal behavior standards
- D. Competence
- E. Professional attributes
- F. Standards of practice
- G. Self-assessment and self-governance
- H. Code of professional ethics
  - I. Ethical concepts
    - 1. Ethical principles
    - 2. Violation process
  - J. Systematic analysis of ethical problems

### II. Ethical Issues in Health Care

- A. Individual and societal rights
- B. Cultural considerations
- C. Economical considerations
- D. Technology and scarce resources
- E. Access to quality health care
- F. Human experimentation and research
- G. End-of-life issues

- H. Ethical research
  - 1. Institutional review board approval
  - 2. Data collection
  - 3. Data reporting
- I. Radiology-specific
  - 1. Dose creep
  - 2. ALARA

### **III. Legal Issues**

- A. Parameters of legal responsibility
- B. HIPAA
  - 1. Confidentiality of patient medical records (written and electronic)
  - 2. Electronic communication (e.g., cell phones, social networking sites, e-mail, photography)
- C. Torts
  - 1. Intentional
  - 2. Unintentional

### **IV. Legal doctrines**

- A. Legal and professional standards
- B. Medical records
  - 1. Accuracy of documentation
  - 2. Radiographic images as legal documents
- C. Legal risk reduction/risk management

### **V. Patient Consent**

- A. Definition
- B. Types
- C. Condition for valid consent
- D. Documentation of consent
- E. Right of refusal

# Human Structure and Function

## Description

Content establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems are described and discussed. The fundamentals of sectional anatomy relative to routine radiography are addressed.

## Content

### I. Anatomical Nomenclature

- A. Terms of direction
  - 1. Anterior/posterior
  - 2. Ventral/dorsal
  - 3. Medial/lateral
  - 4. Superior/inferior
  - 5. Proximal/distal
  - 6. Cephalad/caudad
  
- B. Body planes
  - 1. Median/midsagittal
  - 2. Sagittal
  - 3. Coronal
  - 4. Transverse
  - 5. Longitudinal
  
- C. Body cavities – structural limits, function, contents
  - 1. Cranial
  - 2. Thoracic
  - 3. Abdominal/pelvic

### II. Chemical Composition

- A. Atoms
  
- B. Chemical bonds
  
- C. Inorganic compounds
  - 1. Acids
  - 2. Bases
  - 3. Salts
  - 4. Acid-base balance
  - 5. pH maintenance
  
- D. Organic compounds
  - 1. Carbohydrates
  - 2. Lipids
  - 3. Proteins

4. Nucleic acids
5. DNA
6. RNA
7. Adenosine triphosphate (ATP)
8. Cyclic adenosine 3', 5'-monophosphate (cyclic AMP)

### **III. Cell Structure and Genetic Control**

- A. Cell membrane
  1. Chemistry
  2. Structure
  3. Physiology
  4. Types of transport processes
    - a. Diffusion
    - b. Osmosis
    - c. Filtration
    - d. Active transport/physiological pumps
    - e. Phagocytosis and pinocytosis
- B. Cytoplasm
- C. Organelles
  1. Nucleus
  2. Ribosomes
  3. Endoplasmic reticulum
  4. Golgi complex
  5. Mitochondria
  6. Lysosomes
  7. Peroxisomes
  8. Cytoskeleton
  9. Centrosome and centrioles
  10. Flagella and cilia
- D. Gene action
  1. Protein synthesis
  2. Nucleic acid (RNA/DNA) synthesis
  3. Transcription
  4. Translation
- E. Cell reproduction
  1. Mitosis
  2. Meiosis
- F. Aberration/abnormal cell division

### **IV. Metabolism**

- A. Anabolism

- B. Catabolism
- C. Enzymes and metabolism
- D. Carbohydrate metabolism
- E. Lipid metabolism
- F. Protein metabolism
- G. Regulation and homeostasis

**V. Tissues**

- A. Types of tissue
  - 1. Epithelial
  - 2. Connective
  - 3. Muscle
  - 4. Nerve
- B. Tissue repair

**VI. Skeletal System**

- A. Osseous tissue
  - 1. Structural organization
    - a. Medullary cavity/marrow
    - b. Compact bone
    - c. Cancellous bone
    - d. Periosteum
    - e. Cartilage
  - 2. Development and growth
    - a. Physis
    - b. Diaphysis
    - c. Diaphysis/epiphyseal line
    - d. Metaphysis
  - 3. Classification and markings
    - a. Long
    - b. Short
    - c. Flat
    - d. Irregular
    - e. Processes and bony projections
    - f. Depressions/openings
- B. Divisions
  - 1. Axial
    - a. Skull

- b. Hyoid bone
- c. Vertebral column
- d. Thorax
- 2. Appendicular
  - a. Pectoral girdle
  - b. Upper extremities
  - c. Pelvic girdle
  - d. Lower extremities
- 3. Sesamoids
- 4. Functions
- C. Articulations
  - 1. Types
    - a. Synarthroses, fibrosis
    - b. Amphiarthroses, cartilaginous
    - c. Diarthroses, synovial
  - 2. Movement

## **VII. Muscular System**

- A. Types and characteristics
  - 1. Smooth
  - 2. Cardiac
  - 3. Skeletal

- B. Functions

## **VIII. Nervous System**

- A. Neural tissue – structure and function
  - 1. Neurons
  - 2. Neuroglia
- B. Central nervous system – structure and function
  - 1. Brain and cranial nerves
  - 2. Spinal cord
- C. Peripheral nervous system – structure and function
  - 1. Sympathetic nerves
  - 2. Parasympathetic nerves

## **IX. Sensory System**

- A. General senses
  - 1. Nociperception
  - 2. Chemoreception
  - 3. Thermoreception
  - 4. Mechanoreception

- B. Special senses – structure, function
  - 1. Vision
  - 2. Hearing and equilibrium
  - 3. Olfaction
  - 4. Gustation
  - 5. Tactile

## **X. Endocrine System**

- A. Primary organs - structure, function and location
- B. Homeostatic control
- C. Endocrine tissue and related hormones
  - 1. Pituitary (hypophysis) gland
  - 2. Pineal gland
  - 3. Thyroid gland
  - 4. Parathyroid gland
  - 5. Adrenal (suprarenal) glands
  - 6. Heart and kidneys
  - 7. Digestive system
  - 8. Pancreas
  - 9. Testes
  - 10. Ovaries
  - 11. Thymus
  - 12. Placenta

## **XI. Digestive System**

- A. Primary organs – structure, function and location
  - 1. Oral cavity
  - 2. Esophagus
  - 3. Stomach
  - 4. Small intestine
  - 5. Large intestine
  - 6. Rectum
- B. Accessory organs – structure, function and location
  - 1. Salivary glands
  - 2. Pancreas
  - 3. Liver
  - 4. Gallbladder
- C. Digestive processes
  - 1. Ingestion
  - 2. Peristalsis
  - 3. Digestion
  - 4. Absorption

5. Defecation

## **XII. Cardiovascular System**

- A. Blood
  1. Composition
  2. Clotting system
  3. Hemopoiesis
  4. Function
- B. Heart and vessels
  1. Anatomy
  2. Function
- C. Electrocardiogram (ECG) tracings correlated to normal cardiac rhythm

## **XIII. Lymphatic System and Immunity**

- A. Lymphatic system
  1. Lymph vessels
  2. Lymphatic organs
    - a. Thymus
    - b. Lymph nodes
    - c. Spleen
  3. Lymphatic tissue
    - a. Tonsils
    - b. Peyer's patches
- B. Immune system
  1. Nonspecific defenses
    - a. Physical barriers
    - b. Leukocytes
    - c. Immunological surveillance
  2. B-cell response
    - a. Production
    - b. Types of immunoglobulins
    - c. Function
    - d. Regulation of B-cell response
  3. T-cell response
    - a. Production
    - b. Types
    - c. Function
    - d. Regulation of T-cell response
  4. Passive and active immunity

## **XIV. Respiratory System**

- A. Components, structure and function
  1. Nose and sinus cavities



2. Pharynx
3. Larynx
4. Trachea
5. Bronchi
6. Lungs
7. Thorax

**B. Physiology**

1. Pulmonary ventilation
2. Alveolar gas exchange
3. Transport of blood gases
4. Tissue gas exchange
5. Control and regulation of respiration

**XV. Urinary System**

**A. Components, structure and function**

1. Kidneys
2. Ureters
3. Bladder
4. Urethra

**B. Urine**

1. Physical characteristics
2. Chemical composition

**C. Micturition**

**XVI. Reproductive System**

**A. Male – structure, function and location**

1. External organs
2. Internal organs

**B. Female – structure, function and location**

1. External organs
2. Internal organs
3. Mammary glands

**C. Reproductive physiology**

1. Ovarian cycle
2. Menstrual cycle
3. Aging and menopause

**XVII. Introduction to Sectional Anatomy**

**A. Structures and locations**

1. Head/neck
  - a. Brain

- b. Cranium
- c. Major vessels
- 2. Thorax
  - a. Mediastinum
  - b. Lung
  - c. Heart
  - d. Airway
  - e. Major vessels
- 3. Abdomen
  - a. Liver
  - b. Biliary
  - c. Spleen
  - d. Pancreas
  - e. Kidneys/ureters
  - f. Peritoneum
  - g. Retroperitoneum
  - h. Gastrointestinal (GI) tract
  - i. Major vessels

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# Image Analysis

## Description

Content provides a basis for analyzing radiographic images. Included are the importance of optimal imaging standards, discussion of a problem-solving technique for image evaluation and the factors that can affect image quality. Actual images will be included for analysis.

## Content

### I. Image Appearance Standards

- A. Establishing appearance standards
  - 1. Exam demands
  - 2. Visual acuity/perception
  - 3. Image viewing conditions
  - 4. Radiologist preferences and demands
- B. Maintaining appearance standards-QA program

### II. Imaging Standards

- A. Purpose
- B. Problem-solving process
- C. Role of the radiographer
  - 1. Determining cause of problems
  - 2. Recommending corrective action
- D. Establishing acceptable limits

### III. Image Appearance Characteristics

- A. Brightness/density (film)
  - 1. Exposure to image receptor
  - 2. Brightness on display monitor
- B. Contrast
  - 1. Subject
  - 2. Image
- C. Recorded detail/spatial resolution
  - 1. Motion
  - 2. Geometric
  - 3. Receptor
  - 4. Noise
- D. Distortion
  - 1. Shape

2. Size
3. Spatial

#### **IV. Procedural Factors**

- A. Image identification
  1. Patient information
  2. Date of examination
  3. Proper use of identification markers
  4. Institutional data
  
- B. Documentation of ordered exam
  1. Order types
    - a. Written orders
    - b. Verbal orders
    - c. Electronic orders
  2. Order appropriateness
  
- C. Positioning
  1. Anatomical considerations
    - a. Anatomy of interest
    - b. Plane/baseline reference
    - c. Central ray angulation
    - d. Anatomical variations
    - e. Body habitus
    - f. Pathology
  2. Positioning aids
  3. Special concerns
    - a. Age
    - b. Patient condition
    - c. Mobile radiography
  
- D. Centering
  1. Central ray location
  2. Area of interest
  3. Beam alignment and angulation
  
- E. Exposure indicator appropriateness
  
- F. Radiation protection
  1. Collimation/beam limitation
  2. Shielding
  3. Repeats
  
- G. Patient preparation
  1. Contrast agents
  2. Pre-examination preparation

H. Artifacts

**V. Corrective Action**

A. Equipment

B. Technical factors

C. Procedural factors

D. Artifacts

ASRT

# Imaging Equipment

## Description

Content establishes a knowledge base in radiographic, fluoroscopic and mobile equipment requirements and design. The content also provides a basic knowledge of quality control.

## Content

### I. X-ray Circuit

- A. Electricity
  - 1. Potential difference
  - 2. Current
    - a. Direct
    - b. Alternating
  - 3. Resistance
- B. Protective devices
  - 1. Ground
  - 2. Circuit breaker
- C. Transformers
  - 1. Step-up
  - 2. Step-down
  - 3. Auto transformer
- D. Components and functions
  - 1. Filament circuit
  - 2. Tube circuit
- E. Rectification
  - 1. Purpose
  - 2. Mechanisms
- F. Generator types
  - 1. Single phase
  - 2. High frequency (single and three phase)
    - a. Constant load – constant mA
    - b. Falling load – decreasing mA with time

### II. Radiographic Equipment

- A. Permanent installation
  - 1. Tubes
  - 2. Collimators
  - 3. Tables
  - 4. Control panels
  - 5. Tube stands

6. Wall units
7. Equipment manipulation

**B. Mobile units**

1. Components
2. Purpose
3. Applications

**C. Automatic exposure control (AEC) devices**

1. Ionization chambers
2. Solid state detector
3. Minimum response time
4. Backup time
5. Alignment/positioning considerations
  - a. Cell locations
  - b. Cell size
  - c. Cell sensitivity/balance
6. Compensation issues
  - a. Patient size
  - b. Pathology/metal
  - c. Field size
  - d. Image receptor variations

**III. Diagnostic X-Ray Tubes**

**A. Construction**

**B. Extending tube life**

1. Warm-up procedures
2. Rotor considerations
3. Filament considerations
4. Single exposure limits
5. Multiple exposure limits
6. Anode thermal capacity
7. Tube movement

**IV. Image-Intensified Fluoroscopy**

**A. Construction**

**B. Intensification principles/characteristics**

1. Brightness gain
2. Flux gain
3. Minification gain
4. Automatic brightness control (ABC)
5. Multi-field intensifiers
  - a. Magnification
  - b. Dose

6. Spatial resolution
  7. Contrast
  8. Distortion
  9. Noise
- C. Viewing systems
1. Video camera tube
  2. CCD
  3. CRT/LCD/flat screen monitor
- D. Digital fluoroscopy
1. Types of acquisition
  2. Operations and technique

## **V. Quality Control**

- A. Elements
1. Standards for quality – agencies
  2. Communications
  3. Quality management manual
  4. Responsibility and administration
  5. Test equipment, procedures and training
  6. Record-keeping
  7. Test review
  8. Evaluation
  9. Continuing education
- B. Equipment
1. kVp/half-value layer (HVL)
  2. Milliampere
    - a. mAs reciprocity
    - b. mA linearity
  3. Timer accuracy
  4. Image receptors
  5. Beam alignment
  6. Collimator accuracy
  7. Illuminator brightness/consistency
  8. Monitor calibration

## **VI. Modality Exploration and Radiation Therapy**

- A. Magnetic resonance (MR) imaging, nuclear medicine, ultrasonography, mammography, bone densitometry, interventional radiography
1. Basic principles of operation
  2. Image data presentation/appearance
  3. Education and certification
- B. Radiation therapy



1. Basic principles of treatment delivery (external beam, brachytherapy)
2. Image data presentation/appearance
3. Education and certification

ASRT

# Introduction to Computed Tomography

## Description

Content is designed to provide entry-level radiography students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

## Content

### I. Components, Operations and Processes

- A. Data acquisition
  - 1. Methods
    - a. Slice-by-slice
    - b. Volumetric
  - 2. Elements
    - a. Beam geometry
      - 1) Parallel
      - 2) Fan
      - 3) Spiral
  - 3. Data acquisition system (DAS)
    - a. Components
      - 1) Tube
      - 2) Detectors
      - 3) Filters
      - 4) Collimators
      - 5) ADC
    - b. Functions
      - 1) Measurement of transmitted beam
      - 2) Data transmission to computer
  - 4. Data acquisition process
    - a. Scanning/raw data/image data
      - 1) Rays
      - 2) Views
      - 3) Profiles
        - a) Pixels
        - b) Matrices
        - c) Voxels
    - b. Attenuation
      - 1) Linear attenuation coefficients
      - 2) CT numbers (Hounsfield numbers)
        - a) Baseline reference numbers
          - i) Water equal to 0
          - ii) Bone (white) equal to 400 to 1000 HU
          - iii) Air (black) equal to -1000 HU
    - c. Selectable scan factors
      - 1) Scan field of view

- 2) Display field of view
- 3) Matrix size
- 4) Slice thickness
- 5) Algorithm
- 6) Scan time and rotational arc
- 7) Radiographic tube output
- 8) Region of interest (ROI)
- 9) Magnification
- 10) Focal spot size and tube geometry

B. Factors controlling image appearance

C. Anatomical structures

1. Artifacts
2. Contrast resolution (window width)
3. Grayscale manipulation (window level)
4. Distortion
5. Noise
6. Spatial resolution

**II. Radiation Protection**

A. Methods for reducing radiation dose to the patient

1. Technical factor selection
2. Technical adjustments for children
3. Scatter radiation reduction

B. Reducing the radiographer's exposure to scatter radiation

C. Measurement units in CT

1. CT dose index (CTDI)
2. Multiple scan average dose (MSAD)
3. Dose length product (DLP)

D. CT immobilization devices

1. Straps
2. Head holders
4. IV arm boards

# Introduction to Radiologic Science and Health Care

## Description

Content provides an overview of the foundations of radiography and the practitioner's role in the health care delivery system. Principles, practices and policies of health care organizations are examined and discussed in addition to the professional responsibilities of the radiographer.

## Content

### I. The Health Science Professions

- A. Radiologic technology
  - 1. Radiography disciplines
    - a. Diagnostic radiography
    - b. Computed tomography
    - c. Mammography
    - d. Cardiac-interventional radiography
    - e. Vascular-interventional radiography
    - f. Bone densitometry
    - g. Quality management
    - h. Radiologist assistant
  - 2. Radiation therapy
  - 3. Nuclear medicine technology
  - 4. Multiskilled (fusion technology)
  - 5. Diagnostic medical sonography
  - 6. MR imaging
  - 7. PACS administration/informatics
  - 8. Education
  - 9. Management
- B. Other health care professions

### II. The Health Care Environment

- A. Health care settings
  - 1. Hospitals
  - 2. Clinics
  - 3. Mental health facilities
  - 4. Long-term/residential facilities
  - 5. Hospice
  - 6. Outpatient/ambulatory care
  - 7. Preventive care
  - 8. Home health care
  - 9. Telemedicine
- B. Payment/reimbursement systems
  - 1. Self-pay
  - 2. Insurance

3. Government programs

### **III. Quality Management**

- A. Quality improvement/management
- B. Quality assurance
- C. Quality control
- D. Benefits within radiology
  1. Patient safety
  2. Reduction in radiation exposure
  3. Efficacy of patient care
  4. Departmental efficiency
  5. Consistent image quality
  6. Cost-effectiveness

### **IV. Hospital Organization**

- A. Philosophy
- B. Mission
- C. Administrative services
  1. Governing board
  2. Hospital administration
  3. Admissions
  4. Information systems
  5. Procurement
  6. Accounting
  7. Support services
  8. Human resources
- D. Medical services
  1. Physicians
  2. Clinical services
  3. Clinical support services

### **V. Radiology Organization**

- A. Professional personnel
  1. Administrators/managers
  2. Radiologists
  3. Radiographers
  4. Radiologist assistants
  5. Radiology nurses
  6. Radiation physicists

- B. Support personnel
  - 1. Information systems staff
  - 2. Clerical staff
- C. Educational personnel
  - 1. Program director
  - 2. Clinical coordinator
  - 3. Didactic instructor
  - 4. Clinical instructor
  - 5. Clinical staff

**VI. Accreditation**

- A. Health care institutions
- B. Modalities
- C. Educational
  - 1. Programmatic accreditation (e.g., Joint Review Committee on Education in Radiologic Technology [JRCERT])
  - 2. Regional
  - 3. Other

**VII. Regulatory Agencies**

- A. Federal
- B. State

**VIII. Professional Credentialing**

- A. Certification
- B. Registration
- C. Licensure
- D. Agencies
  - 1. National
  - 2. State

**IX. Professional Organizations**

- A. Purpose, function, activities
- B. Types
  - 1. Local
  - 2. State
  - 3. National
  - 4. International

5. Other

**X. Professional Development and Advancement**

- A. Continuing education
- B. Clinical experience requirements
- C. Continued qualifications
- D. Continuing education opportunities
  - 1. Postprimary certification
  - 2. Collegiate/educational programs
  - 3. Self-learning activities
  - 4. Professional conferences
- E. Employment considerations
  - 1. Geographic mobility
  - 2. Economic factors
  - 3. Workforce needs
- F. Advancement opportunities
  - 1. Education
  - 2. Administration
  - 3. Advanced practice
  - 4. Physics
  - 5. Research
  - 6. Industrial
  - 7. Medical informatics
  - 8. Sales/applications

# Medical Terminology

## Description

Content provides an introduction to the origins of medical terminology. A word-building system is introduced and abbreviations and symbols are discussed. Also introduced is an orientation to understanding radiographic orders and diagnostic report interpretation. Related terminology is addressed.

## Content

### I. The Word-building Process

- A. Basic elements
  - 1. Root words
  - 2. Prefixes
  - 3. Suffixes
  - 4. Combination forms
- B. Parts of speech
  - 1. Nouns
  - 2. Verbs
  - 3. Adjectives
  - 4. Adverbs
- C. Translation of terms into common language
- D. Correct pronunciation of medical terms

### II. Medical Abbreviations and Symbols

- A. Role in communications
- B. Abbreviations
  - 1. Examples
  - 2. Interpretations
- C. Pharmaceutical symbols and terms

### III. Radiologic Technology Procedures and Terminology

- A. Radiography and other imaging modalities
- B. Radiation oncology

### IV. Understanding Orders, Requests and Diagnostic Reports

- A. Radiographic orders and requisitions – components
  - 1. Procedures ordered
  - 2. Patient history
  - 3. Clinical information



- B. Diagnostic reports
  - 1. Content
  - 2. Interpretation

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# Patient Care in Radiologic Sciences

## Description

Content provides the concepts of optimal patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the radiographer in patient education is identified.

## Content

### I. Health Care Team

- A. Responsibilities of the health care facility
  - 1. Caring for all patients regardless of condition
  - 2. Promoting health
  - 3. Preventing illness
  - 4. Education
  - 5. Research
- B. Members and responsibilities
- C. Responsibilities of the radiographer
  - 1. Performing radiographic examination
  - 2. Performing patient care and assessment
  - 3. Adhering to radiation protection guidelines
  - 4. Following practice standards
  - 5. Assisting the radiologist

### II. Professionalism and Communication in Patient Care

- A. Health and illness continuum
- B. Developing professional attitudes
  - 1. Teamwork
  - 2. Work ethic
  - 3. Health role model
  - 4. Sympathy
  - 5. Empathy
  - 6. Assertiveness
- C. Age- and generation-specific communication
  - 1. Neonatal
  - 2. Pediatric
  - 3. Adolescence
  - 4. Young adulthood
  - 5. Middle adulthood
  - 6. Geriatric

D. Communication

1. Verbal
2. Nonverbal communication
3. Language/cultural variations
  - a. Challenges
  - b. Hearing, vision and speech impairments
  - c. Impaired mental function
  - d. Altered states of consciousness
  - e. Human diversity
  - f. Artificial speech
4. Other factors that impede communication
  - a. Colloquialism/slang
  - b. Medical terminology
5. Patient interactions
  - a. Eye contact
  - b. Volume and speed of speech
  - c. Effective listening
  - d. Feedback
6. Communication with families
7. Communication with other health care professionals

E. Psychological considerations

1. Dying and death
  - a. Understanding the process
  - b. Aspects of death
    - 1) Emotional
    - 2) Personal
    - 3) Physical
  - c. Stages of grief
    - 1) Denial
    - 2) Anger
    - 3) Bargaining
    - 4) Depression
    - 5) Acceptance
  - d. Patient support services
    - 1) Family/friends
    - 2) Pastoral care
    - 3) Patient-to-patient support groups
    - 4) Psychological support groups
    - 5) Hospice
    - 6) Home care
2. Factors affecting patient's emotional responses
  - a. Age
  - b. Gender
  - c. Marital/family status
  - d. Socioeconomic factors

- e. Cultural/religious variations
- f. Physical condition
- g. Self-image
- h. Past health care experiences
- i. Beliefs
- j. Attitudes
- k. Prejudices
- l. Self-awareness

### **III. Patient/Radiographer Interactions**

- A. Patient identification methods
  - 1. Interviewing/questioning
  - 2. Chart/requisition
  - 3. Wrist band
  - 4. Institution-specific
- B. Procedure questions and explanations
  - 1. Positioning
  - 2. Length of procedure
  - 3. Immobilization devices
  - 4. Machine movement/sounds
- C. Interaction with patient's family members and friends

### **IV. Safety and Transfer Positioning**

- A. Environmental safety
  - 1. Fire
  - 2. Electrical
  - 3. Hazardous materials
  - 4. Radioactive materials
  - 5. Personal belongings
  - 6. Occupational Safety and Health Administration (OSHA)
  - 7. Environmental Protection Agency (EPA)
- B. Body mechanics
  - 1. Proper body alignment
  - 2. Proper movement
- C. Patient transfer and movement
  - 1. Assess the patient's mobility
  - 2. Rules for safe patient transfer
  - 3. Wheelchair transfers
  - 4. Stretcher transfers
    - a. Sheet transfer
    - b. Three-carrier lift
    - c. Log roll

- d. Positioning for safety, comfort or exams
- e. Transfer devices

D. Fall prevention

E. Patient Positions

- 1. Supine
- 2. Prone
- 3. Decubitus
- 4. Oblique
- 5. Fowler's
- 6. Semi-Fowler's
- 7. Sims'
- 8. Trendelenburg
- 9. Lithotomy

F. Safety and immobilization

- 1. Types
- 2. Applications
- 3. Devices
  - a. Adult
  - b. Pediatric

G. MR Safety

- 1. Pacemakers and other implanted devices
- 2. Aneurysm clips
- 3. O<sub>2</sub> containers

H. Incident reporting

- 1. Legal considerations
- 2. Documentation
- 3. Procedures

**V. Evaluating Physical Needs**

A. Assess patient status

- 1. Evaluation methodology
- 2. Clinical information

B. Vital signs – ranges and values

- 1. Temperature
- 2. Pulse
- 3. Respiration
- 4. Blood pressure
- 5. Normal values
- 6. Interfering factors
- 7. Terminology

8. Adult vs. pediatric
  9. Documentation
  10. Pain assessment
  11. Body type
- C. Acquiring and recording vital signs
1. Procedures
  2. Demonstration
- D. Normal ranges of laboratory data
1. Blood urea nitrogen (BUN)
  2. Creatinine
  3. Glomerular filtration rate (GFR)
  4. Hemoglobin
  5. Red blood cells (RBCs)
  6. Platelets
  7. Oxygen (O<sub>2</sub>) saturation
  8. Prothrombin
  9. Partial thromboplastin time
- E. Patient chart (paper and electronic)
1. Aspects of patient chart
  2. Retrieval of specific information
  3. Proper documentation in the chart

## **VI. Infection Control**

- A. Terminology
1. Hospital acquired
  2. Communicable
  3. Infectious pathogens
  4. Human immunodeficiency virus (HIV)
  5. Hepatitis
  6. Multidrug-resistant organisms (MDRO)
  7. Other
- B. Centers for Disease Control and Prevention (CDC)
1. Purpose
  2. Publications and bulletins
- C. Cycle of infection
1. Infectious pathogens – bloodborne and airborne
  2. Reservoir of infection
  3. Susceptible host
  4. Transmission of disease
    - a. Direct
    - b. Indirect

- D. Prevent disease transmission
  - 1. Transmission-based precautions
  - 2. Health care worker
    - a. Immunization
    - b. Booster
    - c. Post-exposure protocols
  
- E. Asepsis
  - 1. Medical
    - a. Hand washing
    - b. Chemical disinfectants
  - 2. Surgical
    - a. Growth requirements for microorganisms
    - b. Methods used to control microorganisms
      - 1) Moist heat
      - 2) Dry heat
      - 3) Gas
      - 4) Chemicals
    - c. Procedures
      - 1) Opening packs
      - 2) Gowning/gloving
      - 3) Skin preparation
      - 4) Draping
      - 5) Dressing changes
    - d. Packing
    - e. Storage
    - f. Linen
  
- F. Isolation techniques and communicable diseases
  - 1. Category-specific
  - 2. Disease-specific
  - 3. Standard precautions
  
- G. Isolation patient in radiology department
  - 1. Procedure
    - a. Gowning
    - b. Gloving
    - c. Masking
  - 2. Patient transfer
  - 3. Cleaning and proper disposal of contaminated waste
  - 4. Cleaning image receptors and imaging equipment
  
- H. Precautions for the compromised patient (reverse isolation)
  - 1. Purpose
  - 2. Procedure

I. Psychological considerations

## **VII. Medical Emergencies**

A. Terminology

B. Emergency equipment

C. Latex reactions

D. Shock

1. Signs and symptoms

2. Types

a. Hypovolemic

1) Hemorrhage

2) Plasma loss

3) Drugs

b. Disruptive

1) Anaphylactic

2) Neurogenic

3) Septic

c. Cardiogenic

3. Medical intervention

E. Diabetic emergencies – signs, symptoms and interventions

1. Hypoglycemia

2. Ketoacidosis

3. Hyperosmolar coma

F. Respiratory and cardiac failure – signs, symptoms and interventions

1. Adult vs. pediatric

2. Equipment

G. Airway obstruction – signs, symptoms and interventions

H. Cerebral vascular accident (stroke) – signs, symptoms and interventions

I. Fainting and convulsive seizures – signs, symptoms and interventions

1. Types

a. Nonconvulsive (petit mal)

b. Convulsive (grand mal)

2. Reasons for fainting

J. Other medical conditions

1. Epistaxis

2. Nausea

3. Postural hypotension



4. Vertigo
5. Asthma

### **VIII. Trauma**

- A. Head injuries
  1. Four levels of consciousness
  2. Symptoms
  3. Medical intervention
  
- B. Spinal injuries
  1. Assessment
  2. Symptoms
  3. Medical intervention
  4. Transportation
  
- C. Extremity fractures
  1. Types
  2. Symptoms
  3. Orthopedic devices
  4. Positioning
  
- D. Wounds
  1. Symptoms
  2. Medical intervention
  
- E. Burns
  1. Classifications
  2. Medical intervention

### **IX. Contrast Studies**

- A. Patient education
  1. Radiographer's responsibility
  2. Standard procedure
  
- B. Patient preparation and care per procedure
  
- C. Follow-up care
  1. Post exam
  2. Infiltrate

### **X. Reactions to Contrast Agents**

- A. Signs and symptoms
  
- B. Medical intervention
  
- C. Vasovagal reactions

## **XI. Tubes, Catheters, Lines and Other Devices**

- A. Terminology
- B. Function of devices
- C. Nasogastric/nasointestinal
- D. Suction
  - 1. Adult vs. pediatric
  - 2. Special precautions
- E. Tracheostomy
  - 1. Suction techniques
  - 2. Cardiopulmonary resuscitation (CPR) with tracheostomy
- F. Chest (thoracostomy) tube
  - 1. Purpose
  - 2. Location
- G. Implanted devices (pacemakers)
  - 1. Purpose
  - 2. Location
- H. Greenfield filter (IVL filter)
  - 1. Purpose
  - 2. Location
- I. Peripheral venous lines
  - 1. Purpose
  - 2. Location
- J. Central venous lines
  - 1. Purpose
  - 2. Types
  - 3. Access
- K. Tissue drains
- L. Oxygen administration
  - 1. Values
  - 2. Oxygen therapy
  - 3. Oxygen delivery systems
    - a. Low-flow systems
    - b. High-flow systems
  - 4. Documentation

- 5. Special precautions
- M. Urinary collection
  - 1. Procedure
    - a. Male
    - b. Female
  - 2. Alternative methods of urinary drainage
  - 3. Documentation
- N. Ostomies
  - 1. Ileostomy
  - 2. Ureteroileostomy

## **XII. Mobile and Surgical Radiography**

- A. Prior to bedside procedure:
  - 1. Verify order
  - 2. Right patient – right procedure
- B. Steps followed during bedside procedure
- C. Bedside procedure for neonate
- D. Bedside procedure for the orthopedic patient
- E. Special situations
- F. Radiography in surgery
  - 1. Surgical clothing
  - 2. Equipment preparation
  - 3. Sterile fields
  - 4. Communication skills
- G. Radiation protection
  - 1. Patient
  - 2. Radiographer
  - 3. Other

# Pharmacology and Venipuncture

## Description

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

## Considerations

Students should successfully complete patient care objectives (including CPR and basic life support (BLS) certification), as well as objectives related to the anatomy and physiology of the circulatory and excretory systems, prior to introducing this educational content.

Though regulations regarding the administration of contrast media and intravenous medications vary between states and institutions, the official position of the American Society of Radiologic Technologists is that venipuncture falls within the radiologic technology profession's general scope of practice and practice standards. Therefore, it should be included in the didactic and clinical curriculum included with demonstrated competencies in all appropriate disciplines regardless of the state or institution where the curriculum is taught.

In states or institutions where students are permitted to perform intravenous injections, the program has specific ethical and legal responsibilities to the patient and the student. The student shall be assured that:

- Legal statutes allow student radiographers to perform venipuncture.
- Professional liability coverage is adequate.
- Adequate supervision is provided.
- Appropriate, structured laboratory objectives are identified.
- Evaluation and demonstration of competency occur before venipuncture is performed unsupervised.

## Content

### I. Drug Nomenclature

- A. Chemical name
- B. Generic name
- C. Trade name

### II. Methods of Drug Classification

- A. Chemical group
- B. Mechanism/site of action
- C. Primary effect

### **III. General Pharmacologic Principles**

- A. Pharmacokinetics
- B. Pharmacodynamics

### **IV. Six Rights of Drug Safety**

- A. The right medication
- B. The right dose
- C. The right patient
- D. The right time
- E. The right location
- F. The right documentation

### **V. Drug Categories of Relevance to Radiography (Uses and Impacts on Patient)**

- A. Analgesics
- B. Anesthetic agents
- C. Antiallergic and antihistamine drugs
- D. Antianxiety drugs
- E. Antiarrhythmic drugs
- F. Antibacterial drugs
- G. Anticoagulant and coagulant drugs
- H. Antidepressants
- I. Antiemetic drugs
- J. Antihypertensive drugs
- K. Anti-inflammatory drugs
- L. Antiseptic and disinfectant agents
- M. Bronchodilators
- N. Cathartic and antidiarrheal drugs

- O. Diuretics
- P. Sedative and hypotonic drugs
- Q. Vasodilators and vasoconstrictors

## **VI. Contrast Agents**

- A. Types of compound
  - 1. Metallic salts
  - 2. Organic iodides
    - a. Ionic contrast agents
    - b. Nonionic contrast agents
  - 3. Gaseous
- B. Beam attenuation characteristics
  - 1. Radiolucent (negative)
  - 2. Radiopaque (positive)
  - 3. Impact of atomic number
- C. Pharmacologic profile of contrast agents
  - 1. Chemical composition
  - 2. Absorption characteristics
  - 3. Distribution characteristics
  - 4. Metabolic characteristics
  - 5. Elimination characteristics
  - 6. Indications, actions and effects
  - 7. Interactions and contraindications
  - 8. Patient reactions
- D. Dosage
- E. Preparation

## **VII. Routes of Drug Administration**

- A. Systemic
  - 1. Oral
  - 2. Rectal
  - 3. Tube/catheter
  - 4. Inhalation
- B. Parenteral
  - 1. Intravenous
  - 2. Intra-arterial
  - 3. Intrathecal

## **VIII. Venipuncture**

### **A. Methods**

1. Continuous infusion
2. Intermittent infusion
3. Direct injection
  - a. Hand injection
  - b. Mechanical pressure injector

### **B. Sites of administration**

1. Peripheral
2. Central

### **C. Complications**

1. Infiltration
2. Extravasation
3. Phlebitis
4. Air embolism
5. Drug incompatibility
6. Low fluid level in container

### **D. Venipuncture procedures**

1. Equipment
2. Patient identification, assessment and instructions
3. Informed consent
4. Dosage, dose calculations and dose-response
  - a. Adults
  - b. Pediatric patients
5. Patient preparation
6. Application of standard precautions
7. Procedure
  - a. Injection through an existing line
  - b. Venipuncture
8. Site observation
9. Emergency medical treatment procedure
  - a. Appropriate codes
  - b. Emergency cart (crash cart)
  - c. Emergency medications
  - d. Accessory equipment
    - 1) Oxygen
    - 2) Suction
  - e. Emergency medical treatment follow-up tasks
10. Discontinuation
  - a. Equipment/supplies for withdrawal
  - b. Patient preparation
  - c. Application of standard precautions
  - d. Withdrawal procedure

- e. Site observation
- f. Patient observation
- g. Postprocedural tasks
- 11. Documentation of administration
- 12. Documentation of complication/reaction

**IX. Current Practice Status**

- A. Professional standards
  - 1. Scope of practice
  - 2. Practice standards
  - 3. Professional liability and negligence
- B. State statutes
- C. Employer prerogative

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# Principles of Imaging

## Description

Content establishes a knowledge base in factors that govern the image production process.

## Content

### I. Exposure Factors

- A. Distance
- B. mAs
- C. kVp
- D. Grids
- E. Receptor speed

### II. Brightness Digital Display/Density (Film)

- A. Exposure to image receptor
- B. Calculations for receptor exposure maintenance
  - 1. Reciprocity law
  - 2. 15 percent rule
  - 3. Grid factor/Bucky factor
  - 4. Speed class
  - 5. SID

### III. Contrast

- A. Description
  - 1. High/short gray scale
  - 2. Low/long gray scale
- B. Components
  - 1. Subject contrast – variation in receptor exposure
    - a. Structural distribution – anatomical contrast
      - 1) Contrast media
      - 2) Pathology
    - b. Beam quality
      - 1) kVp
      - 2) Filtration
    - c. Scatter control
      - 1) Beam limitation
      - 2) Grid
      - 3) Air gap
  - 2. Image receptor contrast

3. Display contrast
  - a. Brightness
  - b. Ambient light in view area
  - c. Window width and level

#### **IV. Recorded Detail/Spatial Resolution**

- A. Factors affecting recorded detail/spatial resolution
  1. Motion
    - a. Part
    - b. Equipment
  2. Geometric
    - a. Blur width, geometric unsharpness, edge gradient
      - 1) Focal spot size
      - 2) SID
      - 3) Object-to-image distance (OID)
  3. Receptor
    - a. Spatial resolution
    - b. Light diffusion
  4. Noise/mottle

#### **V. Distortion**

- A. Types
  1. Shape
    - a. Foreshortening
    - b. Elongation
  2. Size – geometric magnification
- B. Factors
  - a. Distance
  - b. Tube/part/image receptor relationships

#### **VI. Exposure Latitude**

- A. Factors affecting exposure latitude
  1. kVp
  2. Image receptor

#### **VII. Beam-limiting Devices**

- A. Function/Purpose
  1. Reduce irradiated tissue volume
  2. Reduce patient effective dose
  3. Improve contrast
- B. Types – applications
  1. Cylinders
  2. Collimator
  3. Lead masks

4. Alignment

### **VIII. Beam Filtration**

- A. Types
  1. Inherent
  2. Added
  3. Flat
  4. Compound
- B. Function/mechanism
- C. Compensating filtration
- D. Impact of filtration on image characteristics
- E. Filtration vs. HVL

### **IX. Scattered and Secondary Radiation**

- A. Factors
  1. kVp
  2. Contrast agent
  3. Patient
  4. Beam limitation
  5. Grids
  6. OID – air gap technique
- B. Effects
  1. Effective patient dose
  2. Subject contrast
  3. Image quality
  4. Occupational exposure

### **X. Grids**

- A. Function/mechanism
- B. Construction
- C. Types
  1. Focused
  2. Parallel
  3. Linear
  4. Crossed
  5. Moving
  6. Stationary
  7. Short dimension
  8. Long dimension

- D. Characteristics
  - 1. Focal distance/radius
  - 2. Focal range
  - 3. Ratio
  - 4. Frequency
  - 5. Lead content
  - 6. Grid/Bucky factor
  - 7. Contrast improvement factor
  - 8. Selectivity

- E. Selection
  - 1. kVp
  - 2. Patient/exam
  - 3. Beam limiting
  - 4. Alignment latitude

- F. Primary cutoff

## **XI. Exposure Factor Formulation**

- A. Purpose
  - 1. Receptor exposure standardization
  - 2. Image consistency
- B. Considerations
  - 1. Choice of technique system
  - 2. Patient thickness
  - 3. Image processing
- C. Types
  - 1. Optimum kVp/variable mAs
  - 2. Variable kVp/fixed mAs
  - 3. Automated exposure
  - 4. Anatomically programmed radiography

# Radiation Biology

## Description

Content provides an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

## Content

### I. Introduction

- A. Molecule
  - 1. Ionic bond
  - 2. Covalent bond
  
- B. Basic cellular biology
  - 1. Cellular structure
    - a. Cell membrane
    - b. Cytoplasm
    - c. Protoplasm
    - d. Organelles
    - e. Nucleus
  - 2. Cellular function
    - a. Basic cell chemistry
    - b. Metabolism
    - c. Organic and inorganic compounds
  - 3. Cell proliferation
    - a. Cell cycle
    - b. Mitosis
    - c. Meiosis
    - d. Differentiation
  
- C. Types of ionizing radiation
  - 1. Electromagnetic radiation
    - a. X-rays
    - b. Gamma rays
  - 2. Particulate radiations
    - a. Alpha
    - b. Beta
      - 1) Negatron
      - 2) Positron
    - c. Neutrons
    - d. Protons
  
- D. Sources of medical radiation exposure
  - 1. Diagnostic radiology

2. Dental radiology
3. Cardiovascular-interventional radiology
4. Nuclear medicine
5. Radiation oncology

E. Other sources of radiation exposure

## **II. Radiation Energy Transfer**

A. Molecular effects of radiation

1. Direct effect
  - a. Target theory
    - 1) Target molecules
    - 2) Cell death
2. Indirect effect
  - a. Radiolysis of water

B. Factors effecting energy transfer

1. Linear energy transfer (LET)
2. Relative biological effectiveness (RBE)
3. Factors influencing RBE
  - a. LET
  - b. Oxygen effect

## **III. Radiation Effects**

A. Subcellular radiation effects

1. Radiation effects on DNA
  - a. Types of damage
  - b. Implications for humans
2. Radiation effects of chromosomes
  - a. Types of damage
  - b. Implications for humans

B. Cellular radiation effects

1. Types of cell death
  - a. Interphase death
  - b. Mitotic (genetic) death
2. Other effects
  - a. Mitotic delay
  - b. Reproductive failure
  - c. Interference of function

C. Individual radiation effects

1. Somatic effects
  - a. Short-term
  - b. Long-term
  - c. Stochastic (probabilistic) effects

- d. Nonstochastic (deterministic) effects
- 2. Genetic effects
  - a. Mutagenesis
  - b. Genetically significant dose (GSD)
- 3. Embryo and fetal effects

D. Factors influencing radiation response

**IV. Radiosensitivity and Response**

A. Law of Bergonié and Tribondeau

- 1. Differentiation
- 2. Mitotic rate
- 3. Metabolic rate

B. Cell survival and recovery

- 1. Factors influencing survival
  - a. LET
  - b. Oxygen enhancement ratio (OER)
  - c. Fractionation
  - d. Protraction
- 2. Lethal dose (LD)

C. Systemic response to radiation

- 1. Hemopoietic
- 2. Integumentary
- 3. Digestive
- 4. Urinary
- 5. Respiratory
- 6. Reproductive
- 7. Muscle
- 8. Nervous
- 9. Other

D. Radiation dose-response curves

- 1. Linear, nonthreshold
- 2. Nonlinear, nonthreshold
- 3. Linear, threshold
- 4. Nonlinear, threshold

E. Total body irradiation

- 1. Acute radiation syndrome
  - a. Hemopoietic
  - b. Gastrointestinal
  - c. Central nervous system
- 2. Stages of response and dose levels
- 3. Factors that influence response

4. Medical interventions of response
- F. Late effects of radiation
1. Somatic responses
    - a. Mutagenesis
    - b. Carcinogenesis
  2. Stochastic (probabilistic) effects
  3. Non-stochastic (deterministic) effects
  4. Genetic effects
  5. Occupational risks for radiation workers
- G. Risk estimates

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# Radiation Production and Characteristics

## Description

Content establishes a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

## Content

### I. Structure of the Atom

- A. Composition
  - 1. Nucleus
  - 2. Structure – proton and electron balance
  - 3. Electron shells
    - a. Binding energy
    - b. Valence shell
    - c. Ionization
    - d. Excitation
- B. Nomenclature
  - 1. Atomic number
  - 2. Mass number

### II. Nature of Radiation

- A. Radiation
  - 1. Electromagnetic
    - a. Spectrum
    - b. Wave-particle duality
    - c. Properties
  - 2. Particulate
    - a. Types
    - b. Characteristics
  - 3. Nonionizing (excitation) vs. ionizing
    - a. Energy
    - b. Probability
- B. Radioactivity
  - 1. Radioactive decay
    - a. Alpha emission
    - b. Beta emission
    - c. Gamma emission
  - 2. Half-life ( $T_{1/2}$ )

### III. X-Ray Production

- A. Historical introduction

- B. Target interactions
  - 1. Bremsstrahlung
  - 2. Characteristic
  - 3. Percentage relationship with energy
  
- C. Common terms related to the x-ray beam
  - 1. Primary beam
  - 2. Exit/remnant beam
  - 3. Leakage radiation
  - 4. Off-focus/stem radiation
  
- D. Conditions necessary for x-ray production
  - 1. Source of electrons
  - 2. Acceleration of electrons
  - 3. Focusing the electron stream
  - 4. Deceleration of electrons
  
- E. X-ray emission spectra
  - 1. Continuous spectrum
  - 2. Discrete spectrum
  - 3. Minimum wavelength
  
- F. Factors that affect emission spectra
  - 1. kVp
  - 2. mA
  - 3. Time
  - 4. Atomic number of target
  - 5. Distance
  - 6. Filtration
  - 7. Voltage waveform
  
- G. Efficiency in production
  - 1. Description
  - 2. Frequency and wavelength

#### **IV. Interaction of Photons with Matter**

- A. Transmission of photons
  - 1. Attenuated radiation
  - 2. Exit/remnant radiation
  
- B. Unmodified scattering (coherent)
  
- C. Photoelectric effect
  - 1. Description of interaction
  - 2. Relation to atomic number
  - 3. Energy of incident photon and resulting product

4. Probability of occurrence
    - a. Atomic number
    - b. Photon energy
    - c. Part density
  5. Application
- D. Modified scattering (Compton)
1. Description of interaction
  2. Relation to electron density
  3. Energy
  4. Probability of occurrence
- E. Pair production
- F. Photodisintegration

ASRT

# Radiation Protection

## Description

Content presents an overview of the principles of radiation protection, including the responsibilities of the radiographer for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

## Content

### I. Introduction

- A. Justification for radiation protection
  - 1. Somatic effects
  - 2. Genetic effects
  
- B. Potential biological damage of ionizing radiation
  - 1. Stochastic (probabilistic) effects
  - 2. Nonstochastic (deterministic) effects
  
- C. Objectives of a radiation protection program
  - 1. Documentation
  - 2. Occupational and nonoccupational dose limits
  - 3. ALARA concept (optimization)
  - 4. Comparable risk
  - 5. Negligible individual dose (NID)
  
- D. Sources of radiation
  - 1. Natural
  - 2. Man-made (artificial)
  
- E. Legal and ethical responsibilities

### II. Units, Detection and Measurement

- A. Radiation units
  - 1. Exposure
    - a. Coulomb/kilogram (C/kg) Roentgen (R)
  - 2. Absorbed dose
    - a. Gray (Gy) (Rad)
  - 3. Kerma
    - a. Kinetic energy release in matter
    - b. Measurement unit in the gray
  - 4. Dose equivalent
    - a. Sievert (Sv) (Rem)
  - 5. Measurement units in CT
    - a. CTDI
    - b. MSAD

- c. DLP
- 6. Radioactivity
  - a. Becquerel (Bq)
  - b. Curie (Ci)

B. Dose reporting

- 1. U.S. Nuclear Regulatory Commission (NRC) Regulations (10 Code of Federal Regulations [CFR]) Part 20 Standards for Radiation Protection
- 2. National Council on Radiation Protection and Measurements (NCRP) Guidelines
  - a. Dose quantities
    - 1) Effective dose (E)
    - 2) Collective effective dose (S)
    - 3) Average effective dose to an individual in a group exposed to a specific source (EExp)
    - 4) Effective dose per individual in the U.S. population whether exposed to the specific source or not (EUS)

C. Radiation detectors

- 1. Area monitors
- 2. Personal detectors

**III. Surveys, Regulatory/Advisory Agencies and Regulations**

A. General survey procedures

- 1. Qualified expert
- 2. Records

B. Equipment survey

- 1. Conditions
- 2. Radiographic and fluoroscopic equipment

C. Area survey

- 1. Controlled/uncontrolled areas
- 2. Conditions
- 3. Recommendations
- 4. "Radiation Area" sign posting
- 5. Monitors

D. Regulatory/agencies

- 1. Nuclear Regulatory Commission (NRC)
- 2. Food and Drug Administration (FDA)
- 3. EPA
- 4. OSHA
- 5. State agencies

E. Advisory agencies

- 1. International Council on Radiation Protection and Measurements (ICRP)

2. National Council on Radiation Protection and Measurements (NCRP)
3. Biological Effects of Ionizing Radiation (BEIR)

- F. Radiation safety officer
1. Requirements
  2. Responsibilities

#### **IV. Personnel Monitoring**

- A. Historical perspective
1. Evolution of standards
  2. NRC Regulations (10 CFR) Part 20 Standards for Radiation Protection
  3. NCRP recommendations
  4. ICRP recommendations
- B. Requirements for personnel monitoring
1. Deep dose equivalent (DDE)
  2. Shallow dose equivalent (SDE)
  3. Eye dose equivalent (EDE)
  4. Total effective dose equivalent (TEDE)
- C. Methods and types of personnel monitors
1. Film badge
  2. Thermoluminescent dosimeter (TLD)
    - a. Body badge
    - b. Ring badge
  3. Optically stimulated luminescent dosimeter (OSLD)
- D. Records of accumulated dose
1. Purpose
  2. Content
  3. Length of recordkeeping
  4. Retrieval from previous employers
- E. Effective dose limits
1. Occupational
  2. Nonoccupational limits
  3. Critical organ sites
  4. Embryo and fetus
- F. Responsibilities for radiation protection
1. Radiographer
  2. Radiation safety officer (RSO)
  3. Facility

#### **V. Application**

- A. Design

1. Materials
  2. Primary barrier
  3. Secondary (scatter and leakage) barrier
  4. HVL and tenth-value layer (TVL)
  5. Factors
    - a. Use (U) controlled and uncontrolled
    - b. Workload (W)
    - c. Occupancy (T)
    - d. Distance (D)
  6. X-ray and ancillary equipment
    - a. Beam-limiting devices
    - b. Exposure control devices
    - c. On and off switches
    - d. Interlocks
    - e. Visual/audio monitors
    - f. Emergency controls
    - g. Quality control
      - 1) Calibration
      - 2) Standards
- B. Regulations and recommendations
1. Current NRC recommendations and/or regulations
  2. Current NCRP recommendations and/or regulations
  3. Applicable state regulations
  4. Public Law 97-35 (The Patient Consumer Radiation Health and Safety Act of 1981)
  5. CARE
  6. Public awareness
    - a. Background equivalent radiation time (BERT)
    - b. Social marketing (Image Gently, Image Wisely)
- C. Cardinal principles in protection
1. Time
  2. Distance
  3. Shielding
- D. Emergency procedures

## **VI. Patient Protection**

- A. Beam-limiting devices
- B. Filtration
- C. Shielding
- D. Exposure factors

- E. Positioning
- F. Image receptor system
- G. Immobilization
- H. Fluoroscopic procedures
- I. Mobile radiography
- J. CT
- K. Special considerations
  - 1. Pediatric patients
  - 2. Pregnant patients

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# Radiographic Pathology

## Description

Content introduces concepts related to disease and etiological considerations with emphasis on radiographic appearance of disease and impact on exposure factor selection.

## Content

### I. Definitions/Terminology

- A. Pathology
- B. Disease
  - 1. Acute
  - 2. Chronic
- C. Pathogenesis
- D. Etiology
- E. Diagnosis
  - 1. Signs (objective)
  - 2. Symptoms (subjective)
- F. Prognosis
- G. Indications for procedure
- H. Manifestations of pathology
  - I. Relevance to radiographic procedures
    - 1. Technical considerations
    - 2. Patient considerations

### II. Classifications (Definition, Examples, Sites, Complications, Prognosis)

- A. Mechanics
- B. Chemicals
- C. Thermals
- D. Radiation

### III. Causes of Disease (Process, Examples)

- A. Pathological
- B. Traumatic

- C. Surgical
  - D. Healing process
  - E. Complications
  - F. Genetics (caused by or contributed to by genetic factors) vs. heredity
- IV. Radiologic Pathology (Definitions, Etiology, Examples, Sites, Complications, Prognosis, Radiographic Appearance, Procedural and Technical Considerations, Appropriate Imaging Modality)**
- A. Skeletal
  - B. Digestive
  - C. Respiratory
  - D. Urinary
  - E. Reproductive
  - F. Circulatory
  - G. Endocrine
  - H. Nervous

# Radiographic Procedures

## Description

Content provides the knowledge base necessary to perform standard imaging procedures and special studies. Consideration is given to the evaluation of optimal diagnostic images.

## Content

### I. Standard Terminology for Positioning and Projection

- A. Standard terms
  - 1. Radiographic position
  - 2. Radiographic projection
  - 3. Radiographic view
  
- B. Positioning terminology
  - 1. Recumbent
  - 2. Supine
  - 3. Prone
  - 4. Trendelenburg
  - 5. Decubitus
  - 6. Erect/upright
  - 7. Anterior position
  - 8. Posterior position
  - 9. Oblique position
  
- C. General planes
  - 1. Sagittal or midsagittal
  - 2. Coronal or midcoronal
  - 3. Transverse
  - 4. Longitudinal
  
- D. Skull lines
  - 1. Glabellomeatal line
  - 2. Interpupillary line
  - 3. Orbitomeatal line
  - 4. Infraorbitomeatal line
  - 5. Acanthiomeatal line
  - 6. Mentomeatal line
  
- E. Skull landmarks
  - 1. Auricular point
  - 2. Gonion (angle)
  - 3. Mental point
  - 4. Acanthion
  - 5. Nasion
  - 6. Glabella

7. Inner canthus
8. Outer canthus
9. Infraorbital margin
10. Occlusal plane
11. External auditory meatus
12. Mastoid tip

F. Terminology of movement and direction

1. Cephalad/caudad
2. Inferior/superior
3. Proximal/distal
4. Plantar/palmar
5. Pronate/supinate
6. Flexion/extension
7. Abduction/adduction
8. Inversion/eversion
9. Medial/lateral

G. Positioning aids

1. Sponges
2. Sandbags
3. Immobilization devices

H. Accessory equipment

1. Calipers
2. Lead strips
3. Lead shields or shadow shields
4. Lead markers
5. Image receptor holders

## II. General Considerations

A. Evaluation of radiographic orders

1. Patient identification
2. Verification of procedure(s) ordered
3. Review of clinical history
4. Clinical history and patient assessment
  - a. Role of the radiographer
  - b. Questioning skills
  - c. Chief complaint
  - d. Allergy history
  - e. Localization
  - f. Chronology
  - g. Severity
  - h. Onset
  - i. Aggravating or alleviating factors
  - j. Associated manifestations

- k. Special considerations
- 5. Exam sequencing
  
- B. Room preparation
  - 1. Cleanliness, organization and appearance
  - 2. Necessary supplies and accessory equipment available

### **III. Patient Considerations**

- A. Establishment of rapport with patient
  - 1. Patient education
    - a. Communication
    - b. Common radiation safety issues and concerns
  - 2. Cultural awareness
  - 3. Determination of pregnancy
  
- B. Patient preparation
  - 1. Verification of appropriate dietary preparation
  - 2. Verification of appropriate medication preparation
  - 3. Appropriate disrobing and gowning
  - 4. Removal of items that may cause artifacts
  
- C. Patient assistance
  
- D. Patient monitoring
  
- E. Patient dismissal

### **IV. Positioning Considerations for Routine Radiographic Procedures**

- A. Patient instructions
  
- B. Image analysis
  - 1. Patient positioning
  - 2. Part placement
  - 3. Image receptor selection and placement
  - 4. Beam-part-receptor alignment
  - 5. Beam restriction and shielding
  
- C. Special considerations
  - 1. Atypical conditions
  - 2. Mobile procedures
  - 3. Surgical unit procedures
  - 4. Special needs patients
  - 5. Trauma
  - 6. Obesity
  - 7. Cultural awareness
  - 8. Claustrophobia

D. Positioning for the following studies:

1. Skeletal system
  - a. Upper extremity
    - 1) Fingers
    - 2) Hand
    - 3) Wrist
    - 4) Forearm
    - 5) Elbow
    - 6) Humerus
  - b. Shoulder
    - 1) Shoulder joint
    - 2) Scapula
    - 3) Clavicle
    - 4) Acromioclavicular articulations
  - c. Lower extremity
    - 1) Toes
    - 2) Foot
    - 3) Ankle
    - 4) Calcaneus
    - 5) Tibia/fibula
    - 6) Knee
    - 7) Patella
    - 8) Femur
  - d. Pelvic girdle
    - 1) Pelvis
    - 2) Hip
  - e. Vertebral column
    - 1) Cervical
    - 2) Thoracic
    - 3) Lumbar
    - 4) Sacrum
    - 5) Coccyx
    - 6) Sacroiliac articulations
    - 7) Scoliosis survey
  - f. Bony thorax
    - 1) Ribs
    - 2) Sternum
    - 3) Sternoclavicular articulations
  - g. Cranium
    - 1) Skull
    - 2) Facial bones
    - 3) Nasal bones
    - 4) Orbits/optic foramina
    - 5) Zygomatic arches
    - 6) Mandible

- 7) Temporomandibular articulations
- 8) Paranasal sinuses
- h. Special studies
  - 1) Bone survey
  - 2) Long bone measurement
  - 3) Bone age
  - 4) Foreign body
- 2. Respiratory system
  - a. Upper airway
  - b. Chest
- 3. Abdominal viscera
  - a. Abdomen and GI series
  - b. Urological studies

## **V. Procedural Considerations for Contrast Studies**

- A. Equipment and materials needed
- B. Contrast media
  - 1. Purpose
  - 2. Types
    - a. Negative agents
      - 1) Carbon dioxide
      - 2) Air
      - 3) Nitrous oxide
    - b. Positive agents
      - 1) Barium sulfate
      - 2) Iodinated
- C. General procedure and follow-up care
- D. Patient and body part positioning
- E. Structures and functions demonstrated
- F. Positioning for GI and genitourinary (GU) procedures
  - 1. Digestive system
    - a. Single and double contrast examinations
      - 1) Upper gastrointestinal system
      - 2) Lower gastrointestinal system
    - b. Swallowing dysfunction study
    - c. Small bowel
  - 2. Biliary system
    - a. Endoscopic retrograde cholangiographic pancreatography (ERCP)
    - b. Cholangiography
      - 1) Operative cholangiography
      - 2) T-tube cholangiography

3. Genitourinary system
  - a. Intravenous urography
  - b. Retrograde urography
  - c. Cystography and cystourethrography
  - d. Hysterosalpingography

G. Procedural considerations for the following special studies:

1. Arthrography
2. Myelography

**VI. Additional Imaging Modalities and Radiation Therapy**

A. CT, MR, nuclear medicine, ultrasonography, mammography, bone densitometry, interventional radiography

1. Complement to diagnostic radiography
2. Diagnostic advantages over routine radiography
3. Sample exams(s) or procedure(s)
  - a. Patient preparation
  - b. Patient risk factors

B. Radiation therapy

1. Complement to diagnostic radiography
2. Principles of therapeutic and palliative radiation therapy
3. Sample exam(s) or procedure(s)
  - a. Patient preparation
  - b. Patient risk factors



## Required General Education

General education is an integral part of the development of a professional radiographer. The content is designed to assist in developing skills in communication, human diversity, scientific inquiry, critical thinking and judgment that are required to perform the responsibilities of an entry-level radiographer. Knowledge gained from general education serves to enhance the content and application of the radiography curriculum.

An additional goal of general education is to assist students in acquiring these types of skills. Postsecondary general education content is included as a “required” element of this radiography curriculum instead of as a “recommended” element. General education provides personal enrichment and exploration outside the confines of the technical professional curriculum. The general education content objectives in this curriculum were purposely labeled “global content objectives” to give program officials flexibility in determining specific college-level credit-bearing course work that will satisfy these objectives. There must be a minimum of 15 credit hours of general education course work. Written/oral communications and mathematics/analytical studies are required to satisfy a portion of the 15-credit-hour requirement. For the balance of general education credits, institutions are encouraged to draw upon varying areas of study to ensure a diversified educational experience (e.g., social/behavioral sciences, natural sciences, computing or humanities/fine arts).

Postsecondary general education is to be gained through college credit-bearing courses that meet the global content objectives listed below:

- Mathematical/logical reasoning (required).
  - Develop skills in analysis, quantification and synthesis.
  - Apply problem-solving or modeling strategies.
- Written/oral communications (required).
  - Write and read critically.
  - Speak and listen critically.
  - Develop the ability to perceive, gather, organize and present information.
  - Locate, evaluate and synthesize material from diverse sources and points of view.
- Arts and humanities.
  - Develop knowledge and understanding of the human condition.
  - Demonstrate respect for diverse populations.
  - Develop an understanding of ethics and the role they play in personal and professional lives.
  - Recognize and critically examine attitudes and values.
- Information systems.
  - Develop the knowledge base to use computerized systems.
  - Use technology to retrieve, evaluate and apply information.

- Social/behavioral sciences.
  - Assist in adapting interactions to meet cultural/psychological needs of people.
  - Develop an understanding of individual and collective behavior.
  - Promote the development of leadership skills.
  - Develop the capacity to exercise responsible and productive citizenship.
  - Function as a public-minded individual.
  
- Natural sciences.
  - Develop an understanding of the scientific method.
  - Make informed judgments about science-related topics.
  - Develop a scientific vocabulary.

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## Learning Objectives

This list of learning objectives, indexed by content area, serves as a resource for program planners and course managers.

[Clinical Practice](#)

[Digital Image Acquisition and Display](#)

[Ethics and Law in the Radiologic Sciences](#)

[Human Structure and Function](#)

[Image Analysis](#)

[Imaging Equipment](#)

[Introduction to Computed Tomography](#)

[Introduction to Radiologic Science and Health Care](#)

[Medical Terminology](#)

[Patient Care in Radiologic Sciences](#)

[Pharmacology and Venipuncture](#)

[Principles of Imaging](#)

[Radiation Biology](#)

[Radiation Production and Characteristics](#)

[Radiation Protection](#)

[Radiographic Pathology](#)

[Radiographic Procedures](#)

## Clinical Practice

### Objectives

- ◆ Exercise the priorities required in daily clinical practice.
- ◆ Execute medical imaging procedures under the appropriate level of supervision.
- ◆ Adhere to team practice concepts that focus on organizational theories, roles of team members and conflict resolution.
- ◆ Adapt to changes and varying clinical situations.
- ◆ Describe the role of health care team members in responding/reacting to a local or national emergency.
- ◆ Provide patient-centered, clinically effective care for all patients regardless of age, gender, disability, special needs, ethnicity or culture.
- ◆ Integrate the use of appropriate and effective written, oral and nonverbal communication with patients, the public and members of the health care team in the clinical setting.
- ◆ Integrate appropriate personal and professional values into clinical practice.
- ◆ Recognize the influence of professional values on patient care.
- ◆ Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- ◆ Use patient and family education strategies appropriate to the comprehension level of the patient/family.
- ◆ Provide desired psychosocial support to the patient and family.
- ◆ Demonstrate competent assessment skills through effective management of the patient's physical and mental status.
- ◆ Respond appropriately to medical emergencies.
- ◆ Examine demographic factors that influence patient compliance with medical care.
- ◆ Adapt procedures to meet age-specific, disease-specific and cultural needs of patients.
- ◆ Assess the patient and record clinical history.
- ◆ Demonstrate basic life support procedures.
- ◆ Use appropriate charting methods.
- ◆ Recognize life-threatening electrocardiogram (ECG) tracing.
- ◆ Apply standard and transmission-based precautions.
- ◆ Apply the appropriate medical asepsis and sterile technique.
- ◆ Demonstrate competency in the principles of radiation protection standards.
- ◆ Apply the principles of total quality management.
- ◆ Report equipment malfunctions.
- ◆ Examine procedure orders for accuracy and make corrective actions when applicable.
- ◆ Demonstrate safe, ethical and legal practices.
- ◆ Integrate the radiographer's practice standards into clinical practice setting.
- ◆ Maintain patient confidentiality standards and meet HIPAA requirements.
- ◆ Demonstrate the principles of transferring, positioning and immobilizing patients.
- ◆ Comply with departmental and institutional response to emergencies, disasters and accidents.

- ◆ Differentiate between emergency and non-emergency procedures.
- ◆ Adhere to national, institutional and departmental standards, policies and procedures regarding care of patients, providing radiologic procedures and reducing medical errors.
- ◆ Select technical factors to produce quality diagnostic images with the lowest radiation exposure possible.
- ◆ Critique images for appropriate anatomy, image quality and patient identification.
- ◆ Determine corrective measures to improve inadequate images.

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## Digital Image Acquisition and Display

### Objectives

- ◆ Define terminology associated with digital imaging systems.
- ◆ Describe the various types of digital receptors.
- ◆ Describe the response of digital detectors to exposure variations.
- ◆ Compare the advantages and limits of each receptor type.
- ◆ Evaluate the spatial resolution and dose effectiveness for digital radiography detectors.
- ◆ Describe the histogram and the process of histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
- ◆ Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
- ◆ Describe the response of PSP systems to background and scatter radiation.
- ◆ Use appropriate means of scatter control.
- ◆ Avoid grid use errors associated with grid cutoff and Moiré effect.
- ◆ Identify common limitations and technical problems encountered when using PSP systems.
- ◆ Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
- ◆ Associate impact of image processing parameters to the image appearance.
- ◆ Apply the fundamental principles to digital detectors.
- ◆ Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
- ◆ Describe the conditions that cause quantum mottle in a digital image.
- ◆ Formulate a procedure or process to minimize histogram analysis and rescaling errors.
- ◆ Examine the potential impact of digital radiographic systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
- ◆ Describe picture archival and communications system (PACS) and its function.
- ◆ Identify components of a PACS.
- ◆ Define digital imaging and communications in medicine (DICOM).
- ◆ Describe HIPAA concerns with electronic information.
- ◆ Identify common problems associated with retrieving/viewing images within a PACS.

## Ethics and Law in the Radiologic Sciences

### Objectives

- ◆ Discuss the origins of medical ethics.
- ◆ Apply medical/professional ethics in the context of a broader societal ethic.
- ◆ Explain the role of ethical behavior in health care delivery.
- ◆ Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
- ◆ Identify legal and professional standards and relate each to practice in health professions.
- ◆ Identify specific situations and conditions that give rise to ethical dilemmas in health care.
- ◆ Explain select concepts embodied in the principles of patients' rights, the doctrine of informed (patient) consent and other issues related to patients' rights.
- ◆ Explain the legal implications of professional liability, malpractice, professional negligence and other legal doctrines applicable to professional practice.
- ◆ Describe the importance of accurate, complete and correct methods of documentation as a legal/ethical imperative.
- ◆ Explore theoretical situations and questions relating to the ethics of care and health care delivery.
- ◆ Explain legal terms, principles, doctrines and laws specific to the radiologic sciences.
- ◆ Outline the conditions necessary for a valid malpractice claim.
- ◆ Describe institutional and professional liability protection typically available to the radiographer.
- ◆ Describe the components and implications of informed consent.
- ◆ Identify standards for disclosure relative to informed consent.
- ◆ Describe how consent forms are used relative to specific radiographic procedures.
- ◆ Differentiate between civil and criminal liability.
- ◆ Define tort and explain the differences between intentional and unintentional torts.

## Human Structure and Function

### Objectives

- ◆ Discuss the basics of anatomical nomenclature.
- ◆ Describe the chemical composition of the human body.
- ◆ Identify cell structure and elements of genetic control.
- ◆ Explain the essentials of human metabolism.
- ◆ Describe the types and functions of human tissues.
- ◆ Classify tissue types, describe the functional characteristics of each and give examples of their location within the human body.
- ◆ Describe the composition and characteristics of bone.
- ◆ Identify and locate the bones of the human skeleton.
- ◆ Identify bony processes and depressions found on the human skeleton.
- ◆ Describe articulations of the axial and appendicular skeleton.
- ◆ Differentiate the primary and secondary curves of the spine.
- ◆ Summarize the functions of the skeletal system.
- ◆ Label different types of articulations.
- ◆ Compare the types, locations and movements permitted by the different types of articulations.
- ◆ Examine how muscle is organized at the gross and microscopic levels.
- ◆ Differentiate between the structures of each type of muscle tissue.
- ◆ State the function of each type of muscle tissue.
- ◆ Name and locate the major muscles of the skeleton.
- ◆ Differentiate between the structure and function of different types of nerve cells.
- ◆ State the structure of the brain and the relationship of its component parts.
- ◆ Describe brain functions.
- ◆ List the meninges and describe the function of each.
- ◆ Outline how cerebrospinal fluid forms, circulates and functions.
- ◆ Describe the structure and function of the spinal cord.
- ◆ Determine the distribution and function of cranial and spinal nerves.
- ◆ Summarize the structure and function of components that comprise the autonomic nervous system.
- ◆ Describe the structures and functions of the components that comprise the human eye and ear.
- ◆ List the component body parts involved in the senses of smell and taste.
- ◆ List the somatic senses.
- ◆ Define endocrine.
- ◆ Describe the characteristics and functions of the components that comprise the endocrine system.
- ◆ Describe the hard and soft palates.
- ◆ Describe the structure and function of the tongue.



- ◆ Identify the structure, function and locations of the salivary glands.
- ◆ Describe the composition and characteristics of the primary organs of the digestive system.
- ◆ Describe the function(s) of each primary organ of the digestive system.
- ◆ Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
- ◆ Differentiate between peritoneum, omentum and mesentery.
- ◆ List and label the accessory organs of the digestive system and describe their function.
- ◆ Identify the secretions and function of each accessory organ of the digestive system.
- ◆ Explain the purpose of digestion.
- ◆ List the digestive processes that occur in the body.
- ◆ Describe the composition and characteristics of blood.
- ◆ List the types of blood cells and state their functions.
- ◆ Differentiate between blood plasma and serum.
- ◆ Outline the clotting mechanism.
- ◆ List the blood types.
- ◆ Explain the term Rh factor.
- ◆ Explain the antigen/antibody relationship and its use in blood typing.
- ◆ Label the parts of the human heart.
- ◆ Describe the flow of blood through the body and identify the main vessels.
- ◆ Describe the structure and function of arteries, veins and capillaries.
- ◆ Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
- ◆ Outline the major pathways of lymphatic circulation.
- ◆ Correlate cardiac electrophysiology to a normal ECG tracing.
- ◆ Differentiate between nonspecific defenses and specific immunity.
- ◆ Explain antibody production and function.
- ◆ List the different types and functions of T- and B-cells and explain their functions.
- ◆ Label the components of the respiratory system.
- ◆ Describe the physiology and regulation of respiration.
- ◆ Label the parts of the kidneys, ureters, bladder and urethra.
- ◆ Describe the function of each organ of the urinary system.
- ◆ Describe the composition and formation of urine.
- ◆ Explain micturition.
- ◆ Label the anatomy of the male and female reproductive organs.
- ◆ Analyze the function of each of the male and female reproductive organs.
- ◆ Identify major sectional anatomical structures found within the head/neck, thorax and abdomen.

## Image Analysis

### Objectives

- ◆ Discuss the elements of a radiographic image.
- ◆ Identify anatomy on radiographic images.
- ◆ Apply a problem-solving process used for image analysis.
- ◆ Describe an effective image analysis method.
- ◆ Describe the role of the radiographer in image analysis.
- ◆ Apply the process for evaluating images for adequate density/brightness, contrast, recorded detail/spatial resolution and acceptable limits of distortion.
- ◆ Explain how the radiographer determines that an adequate level of penetration has been applied to produce an acceptable image.
- ◆ Summarize the importance of proper positioning.
- ◆ Discuss the impact of patient preparation on the resulting radiographic image.
- ◆ Analyze images to determine the appropriate use of beam restriction.
- ◆ Identify common equipment malfunctions that affect image quality, and corrective action.
- ◆ Differentiate between technical factor problems, procedural factor problems and equipment malfunctions.
- ◆ Critique images for appropriate technical, procedural and pathologic factors, and employ corrective actions if necessary.
- ◆ Differentiate images produced by various modalities.

## Imaging Equipment

### Objectives

- ◆ Define potential difference, current and resistance.
- ◆ Identify the general components and functions of the tube and filament circuits.
- ◆ Compare generators in terms of radiation produced and efficiency.
- ◆ Discuss permanent installation of radiographic equipment in terms of purpose, components, types and applications.
- ◆ Demonstrate operation of various types of permanently installed and mobile radiographic equipment.
- ◆ Discuss mobile units in terms of purpose, components, types and applications.
- ◆ Describe functions of components of automatic exposure control (AEC) devices.
- ◆ Demonstrate proper use of AEC devices.
- ◆ Identify the components of diagnostic x-ray tubes.
- ◆ Explain protocols used to extend x-ray tube life.
- ◆ Explain image-intensified and digital fluoroscopy.
- ◆ Indicate the purpose, construction and application of video camera tubes, CCD and TV monitors.
- ◆ Differentiate between quality improvement/management, quality assurance and quality control.
- ◆ List the benefits of a quality control to the patient and to the department.
- ◆ Discuss the proper test equipment/procedures for evaluating the operation of an x-ray generator.
- ◆ Evaluate the results of basic QC tests.
- ◆ Discuss the basic principles of operation of various imaging modalities and radiation therapy.

## Introduction to Computed Tomography

### Objectives

- ◆ Describe the components of the CT imaging system.
- ◆ Explain the functions of collimators in CT.
- ◆ List the CT computer data processing steps.
- ◆ Define algorithm and explain its impact on image scan factors and reconstruction.
- ◆ Define raw data and image data.
- ◆ Describe the following terms in relation to the CT data acquisition process:
  - Pixel.
  - Matrix.
  - Voxel.
  - Linear attenuation coefficient.
  - CT/Hounsfield number.
  - Partial volume averaging.
  - Window width (ww) and window level (wl).
  - Spatial resolution.
  - Contrast resolution.
  - Noise.
  - Annotation.
  - Region of interest (ROI).
- ◆ Name the common controls found on CT operator consoles and describe how and why each is used.
- ◆ Identify the types and appearance of artifacts most commonly affecting CT images.
- ◆ Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.
- ◆ Describe the general purpose of commonly performed CT studies.
- ◆ Discuss general radiation safety and protection practices associated with examinations in CT.

## Introduction to Radiologic Science and Health Care

### Objectives

- ◆ Identify other health science professions that participate in the patient's total health care.
- ◆ Identify various settings involved in the delivery of health care.
- ◆ Discuss the reimbursement/payment options for health care services.
- ◆ Discuss the role and value of a mission statement to the operation of an institution.
- ◆ Describe relationships and interdependencies of departments within a health care institution.
- ◆ Discuss the responsibilities and relationships of all personnel in the radiology department.
- ◆ Differentiate between quality improvement/management, quality assurance and quality control.
- ◆ Differentiate among accreditation types.
- ◆ Define credentialing, certification, registration, licensure and regulations.
- ◆ Discuss career opportunities and advancement for the radiographer.
- ◆ Identify the benefits of continuing education as related to improved patient care and professional enhancement.

## Medical Terminology

### Objectives

- ◆ Apply the word-building process.
- ◆ Interpret medical abbreviations and symbols.
- ◆ Critique orders, requests and diagnostic reports.
- ◆ Define medical imaging and radiation oncology terms.
- ◆ Translate medical terms, abbreviations and symbols into common language from a medical report.

ASRT

## Patient Care in Radiologic Sciences

### Objectives

- ◆ Identify the responsibilities of the health care facility and members of the health care team.
- ◆ List the general responsibilities of the radiographer.
- ◆ Describe the practice standards for the radiographer as defined by the ASRT and state licensure.
- ◆ Differentiate between culture and ethnicity.
- ◆ Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- ◆ Explain perceptions of dying and death from the viewpoint of both patient and radiographer.
- ◆ Describe the characteristics of each stage of grief.
- ◆ Identify methods for determining the correct patient for a given procedure.
- ◆ Explain the use of various communication devices and systems.
- ◆ Explain specific aspects of a radiographic procedure to the patient.
- ◆ Demonstrate correct principles of body mechanics applicable to patient care.
- ◆ Demonstrate techniques for specific types of patient transfer.
- ◆ Demonstrate select procedures to turn patients with various health conditions.
- ◆ Describe select immobilization techniques for various types of procedures and patient conditions.
- ◆ Describe specific patient safety measures and concerns.
- ◆ Explain the purpose, legal considerations and procedures for incident reporting.
- ◆ Describe methods to evaluate patient physical status.
- ◆ List the information to be collected prior to a patient examination.
- ◆ Describe vital signs and lab values used to assess patient condition, including sites for assessment and normal values.
- ◆ Define terms related to infection control.
- ◆ Describe the importance of standard precautions and isolation procedures, including sources and modes of transmission of infection and disease and institutional control procedures.
- ◆ Identify symptoms related to specific emergency situations.
- ◆ Describe the institution's emergency medical code system and the role of the student during a medical emergency.
- ◆ Explain the age-specific considerations necessary when performing radiographic procedures.
- ◆ Describe appropriate procedures for management of various types of trauma situations.
- ◆ Describe the symptoms and medical interventions for a patient with a contrast agent reaction.
- ◆ Explain the role of the radiographer in patient education.
- ◆ Describe the patient preparation for contrast studies.
- ◆ Identify specific types of tubes, lines, catheters and collection devices.
- ◆ Outline the steps in the operation and maintenance of suction equipment.
- ◆ Outline the steps in the operation and maintenance of oxygen equipment and demonstrate proper use.

- ◆ Demonstrate competency in basic life support (BLS).
- ◆ Describe the steps in performing various mobile procedures.
- ◆ Describe the special problems faced in performing procedures on a patient with a tracheotomy and specific tubes, drains and catheters.
- ◆ Describe the procedure for producing diagnostic images in the surgical suite.
- ◆ Explain the appropriate radiation protection required when performing mobile/surgical radiography.

ASRT



## Pharmacology and Venipuncture

### Objectives

- ◆ Distinguish among the chemical, generic and trade names for drugs in general.
- ◆ Describe pharmacokinetic and pharmacodynamic principles of drugs.
- ◆ Explain the uses and impact of drug categories on the patient.
- ◆ Define the categories of contrast agents and give specific examples for each category.
- ◆ Explain the pharmacology of contrast agents.
- ◆ Describe methods and techniques for administering various types of contrast agents.
- ◆ Identify and describe the routes of drug administration.
- ◆ Demonstrate appropriate venipuncture technique.
- ◆ Differentiate between the two major sites of intravenous drug administration.
- ◆ Identify, describe and document complications associated with venipuncture and appropriate actions to resolve these complications.
- ◆ Discuss the various elements of initiating and discontinuing intravenous access.
- ◆ Differentiate and document dose calculations for adult and pediatric patients.
- ◆ Prepare for injection of contrast agents/intravenous medications using aseptic technique.
- ◆ Explain the current legal status and professional liability issues of the radiographer's role in contrast and/or drug administration.

## Principles of Imaging

### Objectives

- ◆ Discuss practical considerations in setting standards for acceptable image quality.
- ◆ Assess radiographic exposure on radiographic images.
- ◆ Analyze the relationships of factors that control and affect image exposure.
- ◆ Critique the radiographic contrast within various radiographic images.
- ◆ Analyze the relationship of factors that control and affect radiographic contrast.
- ◆ Critique recorded detail on various radiographic images.
- ◆ Analyze the relationships of factors that control and affect recorded detail.
- ◆ Differentiate between size and shape distortion.
- ◆ Perform calculations to determine image magnification and percent magnification.
- ◆ Summarize the relationship of factors that control and affect distortion.
- ◆ Summarize the relationship of factors affecting exposure latitude.
- ◆ Explain the rationale for using beam-limiting devices.
- ◆ Describe the operation and applications for different types of beam-limiting devices.
- ◆ Explain how beam filtration affects x-ray beam intensity, beam quality and resultant patient exposure.
- ◆ Describe the change in the half-value layer (HVL) when filtration is added or removed in the beam.
- ◆ Summarize the relationship of factors affecting scattered and secondary radiation.
- ◆ Evaluate the effects of scattered radiation on the image.
- ◆ Compare grid types.
- ◆ Select the most appropriate grid for a given clinical situation.
- ◆ Interpret grid efficiency in terms of grid ratio and frequency.
- ◆ Summarize the factors that influence grid cutoff.
- ◆ Evaluate grid artifacts.
- ◆ Explain the use of standardized radiographic technique charts.
- ◆ Explain exposure factor considerations involved in selecting techniques.
- ◆ Compare fixed kilovoltage peak (kVp) and variable kVp systems.
- ◆ Apply the reciprocity law to clinical situations.
- ◆ Apply conversion factors for changes in the following areas: distance, grid, image receptors, reciprocity law and 15 percent rule.

## Radiation Biology

### Objectives

- ◆ Differentiate between ionic and covalent molecular bonds.
- ◆ Describe principles of cellular biology.
- ◆ Identify sources of electromagnetic and particulate ionizing radiations.
- ◆ Discriminate between direct and indirect ionizing radiation.
- ◆ Discriminate between the direct and indirect effects of radiation.
- ◆ Identify sources of radiation exposure.
- ◆ Describe radiation-induced chemical reactions and potential biologic damage.
- ◆ Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
- ◆ Identify methods to measure radiation response.
- ◆ Describe physical, chemical and biologic factors influencing radiation response of cells and tissues.
- ◆ Explain factors influencing radiosensitivity.
- ◆ Recognize the clinical significance of lethal dose (LD).
- ◆ Identify specific cells from most radiosensitive to least radiosensitive.
- ◆ Employ dose response curves to study the relationship between radiation dose levels and the degree of biologic response.
- ◆ Examine effects of limited vs. total body exposure.
- ◆ Relate short-term and long-term effects as a consequence of high and low radiation doses.
- ◆ Differentiate between somatic and genetic radiation effects and discuss specific diseases or syndromes associated with them.
- ◆ Discuss stochastic (probabilistic) and nonstochastic (deterministic) effects.
- ◆ Discuss embryo and fetal effects of radiation exposure.
- ◆ Discuss risk estimates for radiation-induced malignancies.
- ◆ Discuss acute radiation syndromes.

## Radiation Production and Characteristics

### Objectives

- ◆ Describe fundamental atomic structure.
- ◆ Explain the processes of ionization and excitation.
- ◆ Describe the electromagnetic spectrum.
- ◆ Describe wavelength and frequency and how they are related to velocity.
- ◆ Explain the relationship of energy, wavelength and frequency.
- ◆ Explain the wave-particle duality phenomena.
- ◆ Identify the properties of x-rays.
- ◆ Describe the processes of ionization and excitation.
- ◆ Describe charged and uncharged forms of particulate radiation.
- ◆ Differentiate between ionizing and nonionizing radiation.
- ◆ Describe radioactivity and radioactive decay in terms of alpha, beta and gamma emission.
- ◆ Compare the production of bremsstrahlung and characteristic radiations.
- ◆ Describe the conditions necessary to produce x-radiation.
- ◆ Describe the x-ray emission spectra.
- ◆ Identify the factors that affect the x-ray emission spectra.
- ◆ Discuss various photon interactions with matter by describing the interaction, relation to atomic number, photon energy and part density, and their applications in diagnostic radiology.
- ◆ Discuss relationships of wavelength and frequency to beam characteristics.
- ◆ Discuss the clinical significance of the photoelectric and modified scattering interactions in diagnostic imaging.

## Radiation Protection

### Objectives

- ◆ Identify and justify the need to minimize unnecessary radiation exposure of humans.
- ◆ Distinguish between somatic and genetic radiation effects.
- ◆ Differentiate between the stochastic (probabilistic) and nonstochastic (deterministic) effects of radiation exposure.
- ◆ Explain the objectives of a radiation protection program.
- ◆ Define radiation and radioactivity units of measurement.
- ◆ Identify effective dose limits (EDL) for occupational and nonoccupational radiation exposure.
- ◆ Describe the ALARA concept.
- ◆ Identify the basis for occupational exposure limits.
- ◆ Distinguish between perceived risk and comparable risk.
- ◆ Describe the concept of the negligible individual dose (NID).
- ◆ Identify ionizing radiation sources from natural and man-made sources.
- ◆ Comply with legal and ethical radiation protection responsibilities of radiation workers.
- ◆ Describe the relationship between irradiated area and effective dose.
- ◆ Describe the theory and operation of radiation detection devices.
- ◆ Identify appropriate applications and limitations for each radiation detection device.
- ◆ Describe how isoexposure curves are used for radiation protection.
- ◆ Identify performance standards for beam-limiting devices.
- ◆ Describe procedures used to verify performance standards for equipment and indicate the potential consequences if the performance standards fail.
- ◆ Describe the operation of various interlocking systems for equipment and indicate potential consequences of interlock system failure.
- ◆ Identify conditions and locations evaluated in an area survey for radiation protection.
- ◆ Distinguish between controlled and non-controlled areas and list acceptable exposure levels.
- ◆ Describe “Radiation Area” signs and identify appropriate placement sites.
- ◆ Describe the function of federal, state and local regulations governing radiation protection practices.
- ◆ Describe the requirements for and responsibilities of a radiation safety officer.
- ◆ Express the need and importance of personnel monitoring for radiation workers.
- ◆ Describe personnel monitoring devices, including applications, advantages and limitations for each device.
- ◆ Interpret personnel monitoring reports.
- ◆ Compare values for individual effective dose limits for occupational radiation exposures (annual and lifetime).
- ◆ Identify anatomical structures that are considered critical for potential late effects of whole body irradiation exposure.
- ◆ Identify effective dose limits for the embryo and fetus in occupationally exposed women.

- ◆ Distinguish between primary and secondary radiation barriers.
- ◆ Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
- ◆ Perform calculations of exposure with varying time, distance and shielding.
- ◆ Discuss the relationship between workload, energy, half-value layer (HVL), tenth-value layer (TVL), use factor and shielding design.
- ◆ Identify emergency procedures to be followed during failures of x-ray equipment.
- ◆ Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
- ◆ Explain the relationship of beam-limiting devices to patient radiation protection.
- ◆ Discuss added and inherent filtration in terms of the effect on patient dosage.
- ◆ Explain the purpose and importance of patient shielding.
- ◆ Identify various types of patient shielding and state the advantages and disadvantages of each type.
- ◆ Use the appropriate method of shielding for a given radiographic procedure.
- ◆ Explain the relationship of exposure factors to patient dosage.
- ◆ Explain how patient position affects dose to radiosensitive organs.
- ◆ Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
- ◆ Select the immobilization techniques used to eliminate voluntary motion.
- ◆ Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
- ◆ Apply safety factors for the patient, health care personnel and family members in the room during radiographic procedures.

## Radiographic Pathology

### Objectives

- ◆ Define basic terms related to pathology.
- ◆ Describe the basic manifestations of pathological conditions and their relevance to radiologic procedures.
- ◆ Discuss the classifications of trauma.
- ◆ Describe imaging procedures used in diagnosing disease.
- ◆ List the causes of tissue disruption.
- ◆ Describe the healing process.
- ◆ Identify complications connected with the repair and replacement of tissue.
- ◆ Describe the various systemic classifications of disease in terms of etiology, types, common sites, complications and prognosis.
- ◆ Describe the radiographic appearance of diseases.
- ◆ Identify imaging procedures and interventional techniques appropriate for diseases common to each body system.
- ◆ Identify diseases caused by or connected to genetic factors.

## Radiographic Procedures

### Objectives

- ◆ Describe standard positioning terms.
- ◆ Demonstrate proper use of positioning aids.
- ◆ Discuss general procedural considerations for radiographic exams.
- ◆ Identify methods and barriers of communication and describe how each may be used or overcome effectively during patient education.
- ◆ Explain radiographic procedures to patients/family members.
- ◆ Modify directions to patients with various communication problems.
- ◆ Develop an awareness of cultural factors that necessitate adapting standard exam protocols.
- ◆ Adapt general procedural considerations to specific clinical settings.
- ◆ Identify the structures demonstrated on routine radiographic and fluoroscopic images.
- ◆ Adapt radiographic and fluoroscopic procedures for special considerations.
- ◆ Simulate radiographic and fluoroscopic procedures on a person or phantom in a laboratory setting.
- ◆ Evaluate images for positioning, centering, appropriate anatomy and overall image quality.
- ◆ Discuss equipment and supplies necessary to complete basic radiographic and fluoroscopic procedures.
- ◆ Explain the patient preparation necessary for various contrast and special studies.
- ◆ Explain the routine and special positions/projections for all radiographic/fluoroscopic procedures.
- ◆ Explain the purpose for using contrast media.
- ◆ Name the type, dosage and route of administration of contrast media commonly used to perform radiographic contrast and special studies.
- ◆ Describe the general purpose of radiographic and fluoroscopic studies.
- ◆ Apply general radiation safety and protection practices associated with radiographic and fluoroscopic examinations.



## Optional Content

This section is intended to decrease the hardship imposed on programs by requiring instructional content that is representative of technologies and technical principles that have been replaced with newer technical systems. It is recognized that traditional technologies are still part of the fabric of many communities. Content in this section will assist program planners wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of a given program and/or local employment market.

The Basic Principles of Computed Tomography content in this section will aid program planners in developing computed tomography instruction beyond a brief introduction to this technology.

ASRT

## Basic Principles of Computed Tomography

### Description

Content provides entry-level radiography students with principles related to computed tomography (CT) imaging.

### Objectives

- ◆ Explain the difference between reconstructing and reformatting an image.
- ◆ Cite the structures demonstrated on commonly performed CT images.
- ◆ Simulate commonly performed CT procedures on a person or phantom.
- ◆ Evaluate images for positioning, centering, appropriate anatomy and overall image quality.
- ◆ Discuss equipment and supplies necessary to complete commonly performed CT procedures.
- ◆ Explain the CT acquisition protocol for commonly performed head/neck, thorax and abdomen procedures.
- ◆ Explain the patient preparation necessary for commonly performed CT contrast studies.
- ◆ Name the type, dosage purpose, and route of contrast administration for common CT procedures.

## **Content**

### **I. Computed Tomography Generations: Capabilities and Limitations**

- A. First
- B. Second
- C. Third
- D. Fourth
- E. Fifth
- F. Spiral
- G. Postprocessing
  - 1. Image reformation
  - 2. Image smoothing
  - 3. Edge enhancement
  - 4. Window level and width

### **II. Clinical Competencies**

- A. Head
- B. Thorax
- C. Abdomen

*Note: Although this may not be seen in the ARRT mandatory or elective radiography clinical competencies, a basic understanding of computed tomography is increasingly expected of new program graduates. In planning student clinical experiences, radiography programs with sufficient local resources are encouraged to provide students with clinical exposure to computed tomography.*

## Film-Screen Image Acquisition and Processing

### Description

Content establishes a knowledge base in factors that govern the image production process. Film imaging with related accessories is emphasized.

### Objectives

- ◆ Describe the effects of storage on image quality.
- ◆ Discuss safelight illumination appropriate for specific image receptor systems.
- ◆ Discuss darkroom-related Occupational Safety & Health Administration (OSHA) standards for health and safety.
- ◆ Discuss the possible causes and health implications of “darkroom chemical sensitivity.”
- ◆ Describe the function of each component of radiographic film.
- ◆ Explain latent image formation.
- ◆ Describe the features of the characteristic curve and explain its purpose.
- ◆ Select the most appropriate image receptor to be used for given clinical situations.
- ◆ Describe various types of image receptor holders.
- ◆ Describe the function of each component of an intensifying screen.
- ◆ Select the most appropriate intensifying screen for given clinical situations.
- ◆ Identify procedures that ensure a long screen life devoid of artifacts and distortion.
- ◆ Analyze the effects of processing on image quality.
- ◆ Identify key components of an automatic film processor.
- ◆ Demonstrate how various film sizes are fed into the film processor.
- ◆ Analyze the steps of the processing cycle by providing the specific action and duration of time for each step.
- ◆ Identify the purpose of a daily quality control program for processors.
- ◆ Identify types of image artifacts and analyze them to determine the cause.
- ◆ Identify common silver recovery methods.

### Content

#### I. Darkroom/Storage Environment

##### A. Location/construction/function

##### B. Darkroom environment

1. Temperature
2. Humidity
3. Ventilation
4. Lighting
  - a. Safelight
    - 1) Filter colors – spectral emission vs. film sensitivity
    - 2) Mounting distance and direction
    - 3) Bulb size/wattage
    - 4) Safelight testing

- b. Overhead light
- 5. Radiation shielding
- 6. Film handling considerations
  
- C. Film storage considerations
  - 1. Temperature
  - 2. Humidity
  - 3. Light
  - 4. Radiation
  - 5. Pressure
  - 6. Inventory control
  
- D. Safety
  - 1. Occupational Safety & Health Administration (OSHA)
  - 2. Material safety data sheet (MSDS)
  - 3. Darkroom chemical sensitivity

## **II. Characteristics of Film**

- A. Properties
  - 1. Contrast
  - 2. Exposure response – speed sensitivity
  - 3. Recorded detail – spatial resolution
  
- B. Latent image formation
  
- C. Response curves – D-LogE, Hurter and Driffield (H&D) or characteristic
  - 1. Speed
  - 2. Control contrast – average gradient
  - 3. Exposure latitude

## **III. Image Receptor Holders and Intensifying Screens**

- A. Cassettes
  - 1. Purpose
  - 2. Construction
  - 3. Loading/unloading
  - 4. Maintenance
  
- B. Intensifying screens
  - 1. Purpose
  - 2. Construction/composition
  - 3. Principles of function
  - 4. Classification
    - a. Phosphor spectral emission
    - b. Absorption efficiency
    - c. Speed
  - 5. Maintenance
    - a. Handling

- b. Cleaning
- c. Evaluating

#### **IV. Automatic Processing**

- A. Purpose
- B. Components
  - 1. Developer
  - 2. Fixer
  - 3. Wash
  - 4. Dryer
- C. Systems
  - 1. Transport
  - 2. Replenishment
  - 3. Recirculation
  - 4. Temperature control
  - 5. Dryer
- D. Film feed
- E. Maintenance/cleaning
- F. Quality control and documentation

#### **V. Artifacts**

- A. Types
- B. Causes
- C. Effects
- D. Preventive/corrective maintenance

#### **VI. Silver Recovery**

- A. Rationale
- B. Methods
  - 1. Electrolytic
  - 2. Metallic replacement/ion exchange
  - 3. Discarded film
- C. Security

## Imaging Equipment

### Description

Content establishes a knowledge base in radiographic, fluoroscopic and mobile equipment requirements and design. The content also provides a basic knowledge of quality control.

### Objectives

- ◆ Apply the basic principles of linear tomography in the patient care setting.

### Content

#### I. Linear Tomography

- A. Purpose
- B. Principles
- C. Equipment
- D. Applications

ASRT

## Introduction to Forensic Radiography

### Description

Content introduces entry-level radiography students to the scientific discipline of forensic radiography.

### Objectives

- ◆ Identify common areas of forensic study enhanced with radiologic imaging.
- ◆ Identify common procedures performed by forensic radiographers.
- ◆ Discuss the importance of producing pre- and postmortem images of comparable quality.
- ◆ Discuss the importance of radiographic images as forms of evidence in a court of law.

### Content

#### I. Scope of Forensic Radiology Radiography

- A. Service
- B. Education
- C. Concerns of public health and safety
- D. Mass casualty
- E. Child abuse
- F. Research
- G. Domestic abuse
- H. Abuse of the elderly
  - I. Human rights abuse, torture, terrorism

#### II. Imaging for Investigative Procedures

- A. Basal skull
- B. Burned remains
- C. Decomposed body
- D. Gunshot wounds
- E. Intraoral investigation
- F. Missile identification



- G. Motor vehicle accidents
- H. Removal of artifacts
- I. Skeletal remains
- J. Unidentified corpse

**III. Legal Responsibilities**

- A. Parameters of legal responsibility
- B. Scope of practice and responsibilities of the forensic assistant
- C. Legal proceedings
- D. Admissibility of scientific evidence
- E. Federal rules of evidence
- F. The expert witness
- G. Discovery and deposition
- H. Testimony in court
- I. Admissibility of radiological images and results

## Sectional Anatomy

### Description

Content begins with a review of gross anatomy of the entire body. Detailed study of gross anatomical structures will be conducted systematically for location, relationship to other structures and function.

Gross anatomical structures are located and identified in axial (transverse), sagittal, coronal and orthogonal (oblique) planes. Illustrations and anatomy images will be compared with MR and CT images in the same imaging planes and at the same level when applicable. The characteristic appearance of each anatomical structure as it appears on a CT, MR and ultrasound image, when applicable, will be stressed.

### Objectives

- ◆ Name the anatomical structures located within the head and neck.
- ◆ Describe the relationship of each anatomical structure in the head and neck to surrounding structures.
- ◆ Describe the function of each anatomical structure in the head and neck.
- ◆ Locate each anatomical structure on CT, MR and ultrasound images in the transverse axial, coronal, sagittal and orthogonal (oblique) cross-sectional imaging planes.
- ◆ Name the anatomical structures located within the thorax.
- ◆ Describe the relationship of each thoracic structure to surrounding structures.
- ◆ Describe the function of each anatomical structure located within the thorax.
- ◆ Locate each anatomical structure of the thorax on CT, MR and ultrasound images in the transverse axial, coronal, sagittal and oblique imaging planes.
- ◆ List and describe the function of each anatomical structure located within the abdomen and pelvis.
- ◆ Describe the relationship of each anatomical structure in the abdomen and pelvis to surrounding structures.
- ◆ Locate each anatomical structure of the abdomen and pelvis on CT, MR, PET and ultrasound images in the axial, coronal, sagittal and oblique planes.
- ◆ Name and describe the function of each anatomical structure located in the upper and lower extremities.
- ◆ Locate each anatomical structure in the upper and lower extremities on CT and MR images in the transverse axial, coronal, sagittal and oblique planes.

### Content

#### I. Head and Brain

- A. Surface anatomy of the brain
  1. Fissures (sulci)
    - a. Longitudinal cerebral
    - b. Lateral (Sylvian)
    - c. Central (of Rolando)
  2. Convolution (gyri)

- a. Precentral
  - b. Postcentral
- B. Sinuses
- 1. Frontal
  - 2. Maxillary
  - 3. Ethmoidal
  - 4. Sphenoidal
- C. Facial bones
- 1. Mandible
  - 2. Maxillae
  - 3. Zygomas
  - 4. Nasal bones
- D. Facial muscles
- E. Cranial bones
- 1. Frontal
  - 2. Ethmoid
    - a. Nasal conchae (turbinates)
    - b. Nasal septum
  - 3. Parietal
  - 4. Sphenoid
    - a. Lesser wings
      - 1) Tuberculum sellae
      - 2) Sella turcica
      - 3) Dorsum sellae
      - 4) Anterior and posterior clinoid process
      - 5) Optic canals
    - b. Greater wings
      - 1) Foramen rotundum
      - 2) Foramen ovale
        - a) Foramen spinosum
  - 5. Occipital
    - a. Foramen magnum
    - b. Internal and external occipital protuberance
    - c. Jugular foramen
  - 6. Temporal
    - a. Zygomatic process
    - b. External auditory meatus (EAM)
    - c. Internal auditory canal
    - d. Mastoid process
    - e. Petrous portion or ridge
- F. Lobes of the brain and midline cerebral hemisphere structures

1. Frontal
  2. Parietal
  3. Occipital
  4. Temporal
  5. Insula (Island of Reil)
  6. Cerebellum
  7. Corpus callosum (genu, rostrum, body and splenium)
  8. Septum pellucidum
  9. Sella turcica
  10. Pineal gland
  11. Falx cerebri
  12. Septum pellucidum
- G. Cranial nerves
1. Olfactory
  2. Optic
  3. Oculomotor
  4. Trochlear
  5. Trigeminal
  6. Abducens
  7. Facial
  8. Vestibulocochlear
  9. Glossopharyngeal
  10. Vagus
  11. Accessory
  12. Hypoglossal
- H. Brainstem and adjoining structures
1. Diencephalon
    - a. Thalamus
    - b. Hypothalamus
    - c. Optic chiasm
    - d. Optic tracts
    - e. Infundibulum (pituitary stalk)
    - f. Pituitary gland
    - g. Mammillary bodies
    - h. Pineal gland
  2. Midbrain
  3. Pons
  4. Medulla oblongata
    - a. Spinal cord
- I. Arteries (Circle of Willis)
1. Vertebral
  2. Basilar
  3. Internal carotid

4. Anterior and posterior communicating
5. Anterior and posterior cerebral
6. Middle cerebral

J. Veins

1. Venous sinuses
  - a. Superior sagittal sinus
  - b. Vein of Galen
  - c. Straight sinus
  - d. Confluence of sinuses (torcular herophili)
  - e. Transverse sinus
  - f. Sigmoid sinus
2. Internal jugular

K. Ventricular system

1. Lateral ventricles (anterior, body, posterior, inferior or temporal and trigone or atrium)
2. Interventricular foramen (of Monro)
3. Third ventricle
4. Cerebral aqueduct (of Sylvius)
5. Fourth ventricle
6. Foramen of Luschka
7. Foramen of Magendie
8. Choroid plexus

L. Meninges

1. Dura mater
  - a. Extensions of the dura mater
    - 1) Falx cerebri
    - 2) Falx cerebelli
    - 3) Tentorium cerebelli
    - 4) Diaphragma sellae
2. Arachnoid
3. Pia mater

M. Basal ganglia

1. Caudate nucleus
2. Putamen
3. Globus pallidus
4. Claustrum
5. Internal capsule
6. External capsule
7. Extreme capsule

N. Orbit

1. Globe

2. Lens
  3. Optic nerve
  4. Lacrimal gland
  5. Lateral rectus muscle
  6. Medial rectus muscle
  7. Superior rectus muscle
  8. Inferior rectus muscle
  9. Superior oblique muscle
  10. Inferior oblique muscle
  11. Orbital fat
  12. Ophthalmic artery
  13. Retinal vein
- O. Anatomical structures of brain
1. Diploe
  2. Subcutaneous soft tissue
  3. Superior sagittal sinus (anterior and posterior)
  4. Central sulcus
  5. Interhemispheric fissure
  6. Falx cerebri
  7. Centrum semiovale
  8. Corpus callosum (genu, rostrum, body and splenium)
  9. Septum pellucidum
  10. Fornix
  11. Sylvian fissure
  12. Insula
  13. Lentiform nucleus (putamen and globus pallidus)
  14. Caudate nucleus (head)
  15. Internal capsule (anterior, body and posterior sections)
  16. External capsule
  17. Claustrum
  18. Hippocampus
  19. Cerebral peduncles
  20. Mammillary bodies
  21. Tentorium cerebelli
  22. Petrous portion or ridge
  23. Cerebellar tonsil
  24. Internal auditory canal (IAC)
  25. Nasal septum
  26. External auditory canal (EAC)
  27. Clivus
  28. Mastoid air cells
- P. Lines of angulation (imaging baselines)
1. Supraorbitomeatal line
  2. Orbitomeatal line

3. Infraorbitomeatal line

Q. Anatomical landmarks

1. Glabella
2. Nasion
3. Acanthion
4. Mental point
5. External auditory meatus (EAM)

**II. Neck**

A. Bones

1. Cervical vertebrae

B. Organs

1. Pharynx
2. Larynx
3. Esophagus
4. Trachea
5. Salivary glands
6. Thyroid gland
7. Parathyroid glands
8. Lymph nodes

C. Vasculature and neurovasculature

1. Carotid arteries
2. Vertebral arteries
3. Jugular veins
4. Carotid sheath

D. Musculature

1. Anterior triangle
2. Posterior triangle

**III. Chest and Mediastinum**

A. Bony thorax

1. Thoracic vertebrae
2. Sternum
3. Ribs
4. Costal cartilages
5. Scapulae
6. Clavicles

B. Pulmonary

1. Apices (lung)
2. Diaphragm
3. Angles

4. Hilum
5. Lobes (lungs)
6. Trachea
7. Carina
8. Primary (mainstem) bronchi
9. Secondary bronchi

C. Mediastinum

1. Thymus gland
2. Heart
  - a. Arteries
  - b. Veins
  - c. Chamber
  - d. Valves
3. Pulmonary vessels
4. Coronary vessels
5. Ascending aorta
6. Aortic arch
7. Branches of the aortic arch
8. Descending (thoracic) aorta
9. Inferior vena cava
10. Esophagus
11. Trachea
12. Thoracic duct
13. Lymph nodes
14. Azygos vein
15. Hemiazygos vein

D. Breasts

E. Musculature

**IV. Abdomen**

A. Diaphragm and openings

1. Aortic hiatus
2. Caval hiatus
3. Esophageal hiatus

B. Surface landmarks and regions

1. Quadrants
  - a. Upper left
  - b. Upper right
  - c. Lower left
  - d. Lower right

C. Addison's planes (regions)



1. Left hypochondric
2. Epigastric
3. Right hypochondric
4. Left lumbar
5. Umbilical
6. Right lumbar
7. Left iliac
8. Hypogastric
9. Right iliac

D. Branches of the abdominal aorta

1. Anterior visceral branches
  - a. Celiac axis
    - 1) Left gastric
    - 2) Splenic
    - 3) Hepatic
2. Superior mesenteric
  - a. Jejunal and ileal
  - b. Inferior pancreaticoduodenal
  - c. Middle colic
  - d. Right colic
  - e. Ileocolic
3. Inferior mesenteric
  - a. Left colic
  - b. Sigmoid
  - c. Superior rectal
4. Lateral visceral branches
  - a. Suprarenal
  - b. Renal
  - c. Testicular or ovarian
5. Parietal branches
  - a. Inferior phrenics
  - b. Lumbar
  - c. Middle sacral
6. Terminal branches
  - a. Common iliacs

E. Tributaries of the vena cava

1. Anterior visceral
  - a. Hepatic veins
2. Lateral visceral
  - a. Right suprarenal
  - b. Renal veins
  - c. Right testicular or ovarian
3. Tributaries of origin
  - a. Common iliacs

- b. Median sacral
- F. Tributaries of the portal vein
  - 1. Splenic
  - 2. Inferior mesenteric
  - 3. Superior mesenteric
    - a. Left gastric
    - b. Right gastric
    - c. Cystic
- G. Abdominal organs and structures
  - 1. Bony structures
    - a. Lumbar vertebrae
  - 2. Abdominal cavity
    - a. Peritoneum
    - b. Peritoneal space
    - c. Retroperitoneum
    - d. Retroperitoneal space
  - 3. Liver
    - a. Hepatic arteries
    - b. Portal venous system
  - 4. Gallbladder and biliary system
  - 5. Pancreas and pancreatic ducts
  - 6. Spleen
  - 7. Adrenal glands
  - 8. Urinary system and tract
    - a. Kidneys
    - b. Ureters
  - 9. Stomach
  - 10. Small intestine
  - 11. Colon
  - 12. Musculature
- V. **Pelvis**
  - A. Bony structures
    - 1. Proximal femur
    - 2. Ilium
    - 3. Ischium
    - 4. Pubis
    - 5. Sacrum
    - 6. Coccyx
  - B. Pelvic vasculature
    - 1. Arterial
      - a. Common iliacs
      - b. Internal iliacs

- c. External iliacs
    - d. Ovarian/testicular
  - 2. Venous
    - a. External iliacs
    - b. Internal iliacs
    - c. Common iliacs
    - d. Ovarian/testicular
- C. Pelvic organs
  - 1. Urinary bladder
    - a. Ureter
    - b. Urethra
  - 2. Small intestine
    - a. Terminal ilium and ileocecal valve
  - 3. Colon
    - a. Ascending
    - b. Descending
    - c. Sigmoid
    - d. Rectum
    - e. Vermiform appendix
  - 4. Female reproductive organs
    - a. Vagina
    - b. Cervix
    - c. Uterus
    - d. Fallopian tubes
    - e. Ovaries
  - 5. Male reproductive organs
    - a. Testes/scrotum
    - b. Prostate gland
    - c. Seminal vesicles
    - d. External to pelvis
      - 1) Penis

## **VI. Musculoskeletal**

- A. Upper extremities
  - 1. Shoulder
    - a. Bony anatomy
      - 1) Clavicle
      - 2) Scapula
      - 3) Humerus
      - 4) Acromioclavicular joint
    - b. Muscles and tendons
      - 1) Deltoid
      - 2) Supraspinatus
      - 3) Infraspinatus
      - 4) Teres minor

- 5) Subscapularis
- 6) Supraspinatus tendon
- 7) Biceps tendon
- c. Labrum and ligaments
  - 1) Glenoid labrum
  - 2) Glenohumeral ligaments
  - 3) Coracoacromial ligament
  - 4) Coracoclavicular ligaments
  - 5) Bursa (subacromial and subdeltoid)
- d. Vascularity
- 2. Elbow
  - a. Bony anatomy
    - 1) Humerus
    - 2) Radius
    - 3) Ulnar
  - b. Muscles and tendons
    - 1) Anterior group
    - 2) Posterior group
    - 3) Lateral group
    - 4) Medial group
  - c. Ligaments
    - 1) Ulnar collateral
    - 2) Radial collateral
    - 3) Annular
  - d. Neurovasculature
    - 1) Brachial artery
    - 2) Radial artery
    - 3) Ulnar artery
    - 4) Basilic vein
    - 5) Cephalic vein
    - 6) Median cubital vein
    - 7) Ulnar nerve
- 3. Hand and wrist
  - a. Bony anatomy
  - b. Phalanges
  - c. Metacarpals
    - 1) Carpal bones
    - 2) Radius
    - 3) Ulnar
  - d. Tendons
    - 1) Palmar tendon group
    - 2) Dorsal tendon group
    - 3) Triangular fibrocartilage complex
  - e. Neurovascular
    - 1) Ulnar artery
    - 2) Ulnar nerve

- 3) Radial artery
- 4) Median nerve

B. Lower Extremities

1. Hip
  - a. Bony anatomy
  - b. Labrum and ligaments
  - c. Muscle groups
  - d. Neurovasculature
2. Knee
  - a. Bony anatomy
  - b. Menisci and ligaments
  - c. Muscles
  - d. Vasculature
3. Foot and Ankle
  - a. Bony anatomy
  - b. Ligaments
  - c. Tendons
  - d. Muscles

ASRT

## Radiologic Science Resources

This list of radiologic science resources will assist educators in sampling the pool of references and study materials that pertain to medical radiography. The resources list should be viewed as a snapshot of available materials. Omission of any one title is not intentional. Because the creation of literature and media related to the field is dynamic, educators are encouraged to search additional sources for recent updates, revisions and additions to this collection of titles.

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*Radiography*. The College of Radiographers, St. Louis, MO.

*Radiologic Science and Education*. Association of Educators in Imaging and Radiological Sciences, Albuquerque, NM.

*Radiologic Technology*. American Society of Radiologic Technologists, Albuquerque, NM.

*Radiology*. Radiological Society of North America, Oak Brook, IL.

# Bachelor of Science in Radiologic Sciences (B.S.R.S.) Core Curriculum

*Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE,  
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# Introduction

The ASRT recognizes the baccalaureate degree as the professional level of radiologic science education. The need for sophisticated imaging management and leadership to respond to the clinical, organizational and fiscal demands facing the health care industry supports the creation of advanced educational and skill development opportunities for imaging and therapeutic practitioners.

Baccalaureate degree programs in radiography currently exist. These programs take on varying models, and content within this document is applicable to any of these program models.

This B.S.R.S. core curriculum is an expression of content that elevates entry-level education and supports multiple post-primary specialty certifications as well as a transition to education in advanced clinical practice. The core content areas should be seen as the essential foundation of any B.S.R.S. program. Sponsors of B.S.R.S. degrees are encouraged to create a favorable environment for graduates of associate degree and certificate programs to transfer into the B.S.R.S. degree track.

The curriculum document consists of three sections: foundations, core content and optional. The foundations section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice.

Elements making up the core should be viewed as the minimum necessary; expansion or addition of areas is encouraged in developing an overall curriculum plan. Items within the core may be modified for regional, state or institutional variations. The descriptions and objectives are general in nature and not all inclusive. Instructors may modify the descriptions and objectives to reflect personal knowledge and experience. Curriculum content in outline form is intended to provide the general aspects that should be covered in the curriculum, while allowing instructor latitude in choosing specific content to make up individual courses. Program faculty should decide whether to combine topics in a single course or divide the information in one content area into separate courses.

The proposed B.S.R.S. core curriculum continues to expand areas found in the entry-level radiography curriculum, such as critical thinking, human diversity, research and communication skills. Students at the B.S.R.S. level engage these topics with more depth and breadth, resulting in a broader knowledge base and skill set than the entry-level radiographer.



## Table of Contents

Foundations.....	1
Core Content.....	3
Advanced Patient Care.....	4
Advanced Sectional Anatomy.....	7
Communication.....	17
Ethics and Diversity.....	20
Health Care Delivery.....	22
Health Care Law and Compliance.....	25
Leadership and Teambuilding.....	29
Pathophysiology.....	31
Patient Information Management.....	37
Pharmacology.....	40
Quality Management.....	46
Research Methods and Information Literacy.....	48
Optional Content.....	52
Educational Principles for Technologists.....	53
Health Care Informatics.....	56
Appendix.....	58
Clinical Practice.....	59
Digital Image Acquisition and Display.....	61
Ethics and Law in the Radiologic Sciences.....	62
Human Structure and Function.....	63
Introduction to Computed Tomography.....	65
Medical Terminology.....	66
Pathophysiology.....	67
Patient Care in Radiologic Sciences.....	68
Pharmacology and Venipuncture.....	70
Radiation Biology.....	71
Radiation Physics.....	72
Radiation Protection.....	74
Sectional Anatomy.....	76
References.....	77

# Foundations

This foundations section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. The content in this section is intended to aid technologists in career planning and program managers in the development of preassessment tools for candidate selection.

## **Clinical Practice**

Content and clinical practice experiences should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of radiologic procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient preparatory to, during and following the radiologic procedure.

## **Digital Image Acquisition and Display**

Content imparts an understanding of the components, principles and operation of digital imaging systems found in diagnostic radiology. Factors that impact image acquisition, display, archiving and retrieval are discussed. Principles of digital system quality assurance and maintenance are presented.

## **Ethics and Law in the Radiologic Sciences**

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

## **Human Structure and Function**

Content establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems are described and discussed. The fundamentals of sectional anatomy relative to routine radiography are addressed.

## **Introduction to Computed Tomography**

Content is designed to provide entry-level radiography students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

## **Medical Terminology**

Content provides an introduction to the origins of medical terminology. A word-building system is introduced and abbreviations and symbols are discussed. Also introduced is an orientation to understanding radiographic orders and diagnostic report interpretation. Related terminology is addressed.



**Pathophysiology**

Content is designed to introduce concepts related to the disease process. An emphasis on etiological considerations, neoplasia and associated diseases in the radiation therapy patient should be presented.

**Patient Care in Radiologic Sciences**

Content provides the concepts of optimal patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the radiographer in patient education is identified.

**Pharmacology and Venipuncture**

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

**Radiation Biology**

Content provides an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

**Radiation Physics**

Content is designed to establish a basic knowledge of physics pertinent to developing an understanding of radiations used in the clinical setting. Fundamental physical units, measurements, principles, atomic structure and types of radiation are emphasized. Also presented are the fundamentals of x-ray generating equipment, x-ray production and its interaction with matter.

**Radiation Protection**

Content presents an overview of the principles of radiation protection, including the responsibilities of the radiographer for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

**Sectional Anatomy**

Content will introduce students to medical imaging methods currently used in the field of radiation therapy. Students will identify normal anatomical structures via a variety of imaging formats. Basic anatomical relationships will be compared using topographical and cross-sectional images.

Refer to Appendix for a detailed list of objectives for each content area.

## Core Content

The B.S.R.S. requires specific knowledge and skills generally not obtained in basic educational programs in radiography. The core content section represents curriculum elements considered essential in educating students in a broader knowledge base and skill set than the entry-level radiographer.

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# Advanced Patient Care

## Description

As the role of the medical imaging professional continues to expand, more knowledge is needed in all areas. Patient care is no exception. Advanced patient care skills are essential elements of providing high-quality patient care. This course focuses on patient education, assessment, communication, preprocedural and postprocedural care and proper charting and documentation. Technologists' responsibilities and intervention in cases of critical patient need also is discussed.

## Objectives

1. Describe the areas required for patient education in medical imaging.
2. Contribute to treatment plan based on patient assessment.
3. Describe the procedure for and importance of obtaining a complete patient clinical history.
4. Perform proper charting and documentation using manual or electronic formats.
5. Analyze a situation requiring drug dispensing to determine the proper drug amount and route of administration.
6. List the parameters used in the current American Heart Association (AHA) Advanced Cardiac Life Support Guidelines.
7. Recognize normal and abnormal cardiac rhythms.



## **Content**

### **I. Patient Education**

- A. Preprocedure
  
- B. Postprocedure

### **II. Assessment of Physiological Parameters of Recommended Vitals**

- A. Introduction to basic patient assessment
  - 1. Subjective, objective, assessment, plan (SOAP format)
  - 2. Chief complaint, history, assessment, rendered treatment, transport/transfer (CHART format)
  
- B. Patient history
  - 1. Setting of the interview
  - 2. Structure of the interview
  - 3. Taking the history
  
- C. Patient assessment
  - 1. Pulse oximetry
  - 2. Level of consciousness
  - 3. Signs of patient distress
  - 4. Assessment of pain level before, during and after exam
  
- D. Components of the cardiac cycle
  - 1. Electrocardiogram (ECG)
    - a. Normal
    - b. Dysrhythmia
  
- E. Visual inspections
  - 1. Skin
  - 2. Eyes
  - 3. Nails

### **III. Charting and Documentation**

- A. Recognizing proper documentation
  
- B. Manual vs. electronic
  
- C. Ethical and legal aspects

### **IV. Procedure Specific Patient Care**

- A. Preprocedural
  
- B. Postprocedural

## **V. Drug Dispensing**

### **A. Routine and emergency situations**

1. Types of drugs to use
2. When to use the drugs

### **B. Drug actions**

1. Therapeutic
2. Adverse effects
  - a. Minor
  - b. Moderate
  - c. Severe
3. Interventions

## **VI. AHA Advanced Cardiac Life Support**

### **A. Technologist role**

### **B. Drugs**

### **C. Cardiac rhythms**

### **D. Life-support**

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# Advanced Sectional Anatomy

## Description

The ability to locate and identify structures in the axial (transverse), sagittal, coronal and orthogonal (oblique) planes is a necessary skill in many imaging and therapeutic modalities. Volumetric data sets and 3-D reconstruction of the body structures are increasingly important to the critical diagnosis and treatment of diseases. To enhance patient care and assist physicians with the prognosis, radiologic science professionals must understand cross-sectional anatomy.

## Objectives

1. Distinguish normal anatomical structures in the transverse or axial, coronal, sagittal and orthogonal (oblique) cross-sectional imaging planes within the:
  - a. Head
  - b. Neck
  - c. Thorax
  - d. Abdomen
  - e. Pelvis
  - f. Body imaging
  - g. Extremities – large joints
2. Distinguish common pathologies recorded on multiplanar images.



## Content

### I. Head and Brain

- A. Surface anatomy of the brain
  - 1. Fissures (sulci)
    - a. Longitudinal cerebral
    - b. Lateral (Sylvian)
    - c. Central (of Rolando)
  - 2. Convolutions (gyri)
    - a. Precentral
    - b. Postcentral
  
- B. Sinuses
  - 1. Frontal
  - 2. Maxillary
  - 3. Ethmoid
  - 4. Sphenoid
  
- C. Facial bones
  - 1. Mandible
  - 2. Maxillae
  - 3. Zygomas
  - 4. Nasal bones
  - 5. Inferior nasal conchae
  - 6. Lacrimal
  - 7. Palatine
  - 8. Vomer
  
- D. Cranial bones
  - 1. Frontal
  - 2. Ethmoid
    - a. Nasal conchae (turbinates)
    - b. Nasal septum
  - 3. Parietal
  - 4. Sphenoid
    - a. Lesser wings
      - 1) Tuberculum sellae
      - 2) Sella turcica
      - 3) Dorsum sellae
      - 4) Anterior and posterior clinoid process
      - 5) Optic canals
    - b. Greater wings
  - 5. Occipital
    - a. Foramen magnum
    - b. Internal and external occipital protuberance
    - c. Jugular foramen

6. Temporal
  - a. Zygomatic process
  - b. External auditory meatus (EAM)
  - c. Internal auditory canal
  - d. Mastoid process
  - e. Petrous portion or ridge
  
- E. Lobes of the brain and midline cerebral hemisphere structures
  1. Frontal
  2. Parietal
  3. Occipital
  4. Temporal
  5. Insula (island of Reil)
  6. Cerebellum
  7. Corpus callosum (genu, rostrum, body and splenium)
  8. Septum pellucidum
  
- F. Cranial nerves
  1. Olfactory
  2. Optic
  3. Oculomotor
  4. Trochlear
  5. Trigeminal
  6. Abducens
  7. Facial
  8. Vestibulocochlear
  9. Glossopharyngeal
  10. Vagus
  11. Accessory
  12. Hypoglossal
  
- G. Brainstem
  1. Diencephalon
    - a. Thalamus
    - b. Hypothalamus
    - c. Optic chiasm
    - d. Optic tracts
    - e. Infundibulum (pituitary stalk)
    - f. Pituitary gland
    - g. Mammillary bodies
    - h. Pineal gland
  2. Midbrain
  3. Pons
  4. Medulla oblongata
    - a. Spinal cord

- H. Arteries of the head and neck (Circle of Willis)
  - 1. Vertebral
  - 2. Basilar
  - 3. Internal carotid
  - 4. Anterior and posterior communicating
  - 5. Anterior and posterior cerebral
  - 6. Middle cerebral
  
- I. Veins
  - 1. Venous sinuses
    - a. Superior sagittal sinus
    - b. Vein of Galen
    - c. Straight sinus
    - d. Confluence of sinuses (torcular herophili)
    - e. Transverse sinus
    - f. Sigmoid sinus
  - 2. Internal jugular
  
- J. Ventricular system
  - 1. Lateral ventricles (anterior, body, posterior, inferior or temporal, and trigone or atrium)
  - 2. Interventricular foramen (of Monro)
  - 3. Third ventricle
  - 4. Cerebral aqueduct (of Sylvius)
  - 5. Fourth ventricle
  - 6. Foramen of Luschka
  - 7. Foramen of Magendie
  - 8. Choroid plexus
  
- K. Meninges
  - 1. Dura mater
    - a. Extensions of the dura mater
      - 1) Falx cerebri
      - 2) Falx cerebelli
      - 3) Tentorium cerebelli
      - 4) Diaphragma sellae
    - b. Spaces
      - 1) Epidural
      - 2) Subdural
      - 3) Subarachnoid
  - 2. Arachnoid
  - 3. Pia mater
  
- L. Basal ganglia
  - 1. Caudate nucleus
  - 2. Putamen

3. Globus pallidus
4. Claustrum
5. Internal capsule
6. External capsule
7. Extreme capsule

M. Orbit

1. Globe
2. Lens
3. Optic nerve
4. Lacrimal gland
5. Lateral rectus muscle
6. Medial rectus muscle
7. Superior rectus muscle
8. Inferior rectus muscle
9. Superior oblique muscle
10. Inferior oblique muscle
11. Orbital fat
12. Ophthalmic artery
13. Retinal vein

N. Anatomical structures of brain

1. Diploe
2. Subcutaneous soft tissue
3. Superior sagittal sinus (anterior and posterior)
4. Central sulcus
5. Interhemispheric fissure
6. Falx cerebri
7. Centrum semiovale
8. Corpus callosum (genu, rostrum, body and splenium)
9. Septum pellucidum
10. Fornix
11. Sylvian fissure
12. Insula
13. Lentiform nucleus (putamen and globus pallidus)
14. Caudate nucleus (head)
15. Internal capsule (anterior, body and posterior sections)
16. External capsule
17. Claustrum
18. Hippocampus
19. Tentorium cerebelli
20. Petrous portion or ridge
21. Cerebellar tonsil
22. Internal auditory canal (IAC)
23. Nasal septum
24. EAM



25. Clivus
26. Mastoid air cells

## **II. Neck**

### **A. Bones**

1. Cervical vertebrae
  - a. Bony structures
  - b. Intervertebral disks
  - c. Spinal cord and nerves
  - d. Spinal ligaments

### **B. Organs**

1. Pharynx
2. Larynx
3. Esophagus
4. Trachea
5. Salivary glands
6. Thyroid gland
7. Parathyroid glands
8. Lymph nodes

### **C. Vasculature and neurovasculature**

1. Carotid arteries
2. Vertebral arteries
3. Jugular veins
4. Carotid sheath

### **D. Musculature**

1. Anterior triangle
2. Posterior triangle

## **III. Chest and Mediastinum**

### **A. Bony thorax**

1. Thoracic vertebrae
  - a. Bony structures
  - b. Intervertebral disks
  - c. Spinal cord and nerves
  - d. Spinal ligaments
2. Sternum
3. Ribs
4. Costal cartilages
5. Scapulae
6. Clavicles

### **B. Pulmonary**

1. Apices (lung)

2. Diaphragm
3. Angles
4. Hilum
5. Lobes (lungs)
6. Trachea
7. Carina
8. Primary (mainstem) bronchi
9. Secondary bronchi

C. Mediastinum

1. Thymus gland
2. Heart
  - a. Coronary vessels and valves
  - b. Musculature and septal walls
  - c. Chambers
  - d. Pulmonary vessels
3. Ascending aorta
4. Aortic arch
5. Branches of the aortic arch
6. Descending (thoracic) aorta
7. Inferior vena cava
8. Esophagus
9. Trachea
10. Thoracic duct
11. Lymph nodes
12. Azygos vein
13. Hemiazygos vein

D. Breasts

E. Musculature

**IV. Abdomen**

A. Bones

1. Lumbar vertebrae
  - a. Bony structures
  - b. Intervertebral disks
  - c. Spinal cord and nerves
  - d. Spinal ligaments

B. Diaphragm and openings

C. Branches of the abdominal aorta

1. Anterior visceral branches
  - a. Celiac axis
    - 1) Left gastric

- 2) Splenic
- 3) Hepatic
- 2. Superior mesenteric artery
  - a. Jejunal and ileal
  - b. Inferior pancreaticoduodenal
  - c. Middle colic
  - d. Right colic
  - e. Ileocolic
- 3. Inferior mesenteric artery
  - a. Left colic
  - b. Sigmoid
  - c. Superior rectal
- 4. Lateral visceral branches artery
  - a. Suprarenal
  - b. Renal
  - c. Testicular or ovarian
- 5. Parietal branches artery
  - a. Inferior phrenics
  - b. Lumbar
  - c. Middle sacral
- 6. Terminal branches
  - a. Common iliacs
- D. Tributaries of the vena cava
  - 1. Anterior visceral
    - a. Hepatic
  - 2. Lateral visceral
    - a. Right suprarenal
    - b. Renal veins
    - c. Right testicular or ovarian
  - 3. Tributaries of origin
    - a. Common iliacs
    - b. Median sacral
- E. Tributaries of the portal vein
  - 1. Splenic
  - 2. Inferior mesenteric
  - 3. Superior mesenteric
    - a. Left gastric
    - b. Right gastric
    - c. Cystic
- F. Abdominal organs and structures
  - 1. Abdominal cavity
    - a. Peritoneum
    - b. Peritoneal space

- c. Retroperitoneum
- d. Retroperitoneal space
- 2. Liver
- 3. Gallbladder and biliary system
- 4. Pancreas and pancreatic ducts
- 5. Spleen
- 6. Adrenal glands
- 7. Urinary system and tract
  - a. Kidneys
  - b. Ureters
- 8. Stomach
- 9. Small intestine
- 10. Colon
- 11. Musculature

## V. Pelvis

- A. Bony structures
  - 1. Proximal femur
  - 2. Ilium
  - 3. Ischium
  - 4. Pubis
  - 5. Sacrum
  - 6. Coccyx
- B. Pelvic vasculature
  - 1. Arterial
    - a. Common iliacs
    - b. Internal iliacs
    - c. External iliacs
    - d. Ovarian/testicular
  - 2. Venous
    - a. External iliacs
    - b. Internal iliacs
    - c. Common iliacs
    - d. Ovarian/testicular
- C. Pelvic organs
  - 1. Urinary bladder
    - a. Ureter
    - b. Urethra
  - 2. Small intestine
    - a. Terminal ilium and ileocecal valve
  - 3. Colon
    - a. Ascending
    - b. Descending
    - c. Sigmoid



- d. Rectum
- e. Vermiform appendix
- 4. Female reproductive organs
  - a. Vagina
  - b. Cervix
  - c. Uterus
  - d. Fallopian tubes
  - e. Ovaries
- 5. Male reproductive organs
  - a. Testes/scrotum
  - b. Prostate gland
  - c. Seminal vesicles
  - d. External to pelvis
    - 1) Penis

## **VI. Extremities**

- A. Joints and associated soft-tissue structures
  - 1. Shoulder
  - 2. Elbow
  - 3. Wrist
  - 4. Hip
  - 5. Knee
  - 6. Ankle

# Communication

## Description

Communication is important because radiologic technologists need to effectively relate and communicate with patients and other health care professionals. Communication with the patient is well established in the entry-level curricula. Therefore, this content focuses on expanding the knowledge base and skills necessary for interpersonal, internal, external and written communications. Human diversity and respect is emphasized.

## Objectives

1. Establish effective communication within the professional environment.
2. Apply communication strategies for conflict management.
3. Create and deliver professional presentations.
4. Integrate the values and beliefs of the profession and organization in daily communications.
5. Compose professional communications in a variety of electronic and written formats.
6. Demonstrate active listening skills.

## **Content**

### **I. Interpersonal Communications**

- A. Health care interactions
  - 1. Professional – patient
  - 2. Professional – professionals
  - 3. Professional – family
  - 4. Patient – family
  
- B. Listening and feedback
  - 1. Hearing vs. listening
  - 2. Active vs. inactive listening
  - 3. Reflecting
  - 4. Feedback
  
- C. Building rapport
  - 1. Self-disclosure
  - 2. Trust
  - 3. Respectful social interactions
  - 4. Respect for human diversity
  - 5. Barriers to communication
  
- D. Negotiation and conflict management
  - 1. Avoidance
  - 2. Accommodating
  - 3. Competitive
  - 4. Cooperation
  - 5. Compromising
  
- E. Interview skills

### **II. Intrapersonal Communication**

- A. Perception
  - 1. Role
  - 2. Past roles and experiences
  - 3. Personality traits
  - 4. Culture
  - 5. Feelings and circumstances
  - 6. Self image
  
- B. Perceptual errors
  - 1. Stereotyping
  - 2. First impressions
  
- C. Defense mechanisms

### **III. Internal and External Communication**

- A. Groups
  - 1. Group types
  - 2. Roles and responsibilities
  - 3. Factors affecting group performance
  
- B. Business communication
  - 1. Message types and structure
  - 2. Electronic communication
  - 3. Channels or hierarchy
  - 4. Telephone/conference calls

#### **IV. Oral Communication**

- A. Speaker preparation
  - 1. Topic identification
  - 2. Audience analysis
  - 3. Environment
  - 4. Approach
  
- B. Speech creation and delivery
  - 1. Topic selection
  - 2. Narrowing a topic
  - 3. Source materials
  - 4. Parts of a speech
  - 5. Informative speech patterns
  - 6. Persuasive speech patterns
  - 7. Supporting materials for clarification
  - 8. Speech delivery
    - a. Appropriate and legal use of media

#### **V. Communication Tools**

- A. Presentation tools
  
- B. Multimedia
  
- C. Mass media

# Ethics and Diversity

## Description

Ethics and diversity are important because all health care providers work in a global community that is increasingly diverse and complex. Health care providers must interact with individuals from a variety of backgrounds both ethically and with respect for their beliefs and values. This content builds on ethical and diverse issues that affect the radiologic technologist as an individual and interactions with patients, coworkers and the community.

## Objectives

1. Assess situations to determine how a radiologic technologist would perform ethically based on personal, societal and professional standards within the United States.
2. Examine situations to determine if the radiologic technologist interacts appropriately and respectfully with a diverse population.

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## **Content**

### **I. Values and Ethics**

- A. Professional
  - 1. Standards
  - 2. Examples
  - 3. Resources for assistance
  
- B. Medical
  - 1. Standards
  - 2. Examples
  - 3. Resources for assistance
  
- C. Research
  - 1. Standards
  - 2. Examples
  - 3. Resources for assistance

### **II. Diversity**

- A. Socioeconomic
- B. Ethnicity
- C. Gender
- D. Sexual orientation
- E. Age
- F. Family structure
- G. Religion
- H. Effects of lifestyle choices and behaviors
  - I. Mentally and physically challenged
  - J. Medical conditions



# Health Care Delivery

## Description

It is important for the radiologic technologist to understand the various methods of health care delivery to remain knowledgeable in the changing face of technology. The political context of health care organization and delivery, with specific focus on the mechanisms for policy formulation and implementation, is discussed.

## Objectives

1. Debate historical perspectives and technological advances as they relate to the delivery of health care.
2. Discriminate between various policy formation and implementation mechanisms and the impact of each on direct patient care.
3. Analyze the various influences of policy on direct patient care.
4. Compare and contrast the different types of health care delivery systems.
5. Differentiate between the components of the U.S. health care delivery system.
6. Explain factors influencing health care delivery.
7. Characterize the sources of research and monitoring in health care delivery.
8. Examine the impact of imaging technology on health care delivery.

## **Content**

### **I. Evolution of the U.S. Health Care System**

- A. Historical perspective
- B. Evolution of national standards
- C. Evolution of state standards
- D. Landmark events

### **II. Health Policy Formulation and Implementation**

- A. National policy-making process
- B. State policy-making process
- C. Policy implementation

### **III. Policy Influences on Direct Patient Care**

- A. National
- B. State
- C. Local
- D. Institutional
  - 1. For profit
  - 2. Not for profit

### **IV. U.S. Health Care Delivery System**

- A. Philosophy/mission
- B. Organizational structure
- C. Recipients of care
- D. Health care providers

### **V. Components of the Health Care Delivery System**

- A. Financing
- B. Insurance
- C. Delivery
- D. Payment



**VI. Sources of Research and Monitoring Health Care Delivery**

- A. International agencies
- B. National agencies
- C. State (academic health centers)
- D. Professional organizations/societies

**VII. Factors Influencing U.S. Health Care Delivery**

- A. Definition of health
- B. Determinates of health
- C. Cultural beliefs and values
- D. Strategies to improve health wellness

**VIII. The Impact of Imaging Technology on Health Care Delivery**

- A. Telecommunication systems
- B. Fusion technologies
- C. Patient information/education resources
- D. Rapid development of technology

# Health Care Law and Compliance

## Description

Health care law and compliance is important because of its impact on technologists, patients and health care facilities. This content is geared toward legal and compliance issues that affect the employee and employer directly regarding accreditation and compliance issues. In addition this content gives guidance on quality management techniques, including reporting, that can help mitigate noncompliance.

## Objectives

1. Analyze various scenarios involving roles and responsibilities of radiologic technologists to determine if they are working within the scope of practice and using appropriate practice standards.
2. Evaluate an existing quality management plan to determine if it complies with effective quality management principles.
3. Determine implications of civil and criminal law upon professional licensing/certification and accreditation.
4. Outline civil procedures followed when a complaint is filed.
5. Analyze a situation to determine the type of patient consent granted.
6. Identify strategies to assure that patient's rights are maintained.
7. Differentiate between the employer's and employee's legal responsibilities.
8. Identify the accreditation and compliance issues relevant to health care facilities.

## **Content**

### **I. Scope of Practice and Practice Standards**

- A. Scope of practice
  - 1. State laws and regulations
    - a. Body of laws
  - 2. National certification
  - 3. Institutional authority
  - 4. National organizations
    - a. Persuasive authority
- B. Practice standards
  - 1. Development and maintenance
  - 2. Use and applications
  - 3. Clinical performance standards
  - 4. Quality performance standards
  - 5. Professional performance standards
  - 6. Advisory opinion statements

### **II. Components of a Quality Improvement Management Program**

- A. Decision making as an outcome of quality improvement analysis
- B. Planning to improve quality and safety
  - 1. Present and future actions
- C. Quality management team
  - 1. Involvement of other departments/agents
  - 2. Application of policy and procedures
  - 3. Assignments
  - 4. Monitoring
  - 5. Assessment
  - 6. Education
  - 7. Outcomes

### **III. Legal Issues**

- A. Civil
- B. Criminal law
- C. Administrative law

### **IV. Civil Procedures**

- A. Pleadings
- B. Summons and complaint
- C. Discovery

- D. Motions
- E. Trial procedure
- F. Evidence
- G. Verdict
- H. Appeals

**V. Burden of proof**

- A. *Res Ipsa Loquitur*
- B. *Respondeat Superior*

**VI. Patient Consent**

- A. Implied
- B. Informed
- C. Uninformed
- D. Research (Institutional Review Board, or IRB)

**VII. Advanced Directives**

- A. Living wills
- B. Do-not-resuscitate orders (DNR)
- C. Power of attorney

**VIII. Employer and Employee Responsibilities**

- A. Labor laws
- B. Unions
- C. Discrimination laws
- D. Workplace harassment
- E. Conditions of employment
  - 1. Position descriptions
  - 2. Drug screening
  - 3. Background checks
  - 4. Misrepresentation

- F. Liability coverage
  - 1. Employer
  - 2. Personal
- G. Equipment safety regulations
- H. Occupational safety and training
- I. Whistleblower protection

**IX. Accreditation and Compliance Issues**

- A. Purpose of accreditation
- B. Health care facility accreditation
  - 1. Federal
  - 2. State
  - 3. Private
- C. Health care professional credentialing
  - 1. Certification
  - 2. Licensure
  - 3. Registration
- D. Credentialing agencies
  - 1. National organizations
  - 2. State agencies
- E. Regulatory agencies
  - 1. Federal
  - 2. State
- F. Advisory agencies
  - 1. International
  - 2. National



# Leadership and Teambuilding

## Description

Leadership and teambuilding are vital components of all health care organizations. To promote an effective team, the radiologic technologist must be able to lead and exercise the ability to function within an interdisciplinary team. It is highly recommended for this information to be applied throughout the curriculum to ensure adequate understanding based on various situations.

## Objectives

1. Evaluate the characteristics of a team as they relate to the effectiveness of the team.
2. Compare and contrast the advantages and disadvantages of a team.
3. Discuss the role of the leader in building effective teams.
4. Identify the skills necessary to be an effective team leader.

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## **Content**

### **I. Nature of Teams**

- A. Philosophy and guiding principles of a team
  - 1. Vision
  - 2. Mission
  - 3. Goals

### **II. Team Utilization**

- A. Advantages
- B. Disadvantages
- C. Limitations
- D. Continuous quality improvement

### **III. Leadership**

- A. Leadership role
  - 1. Facilitator
  - 2. Power
  - 3. Effectiveness
  - 4. Conflict management and resolution
  - 5. Mentoring
- B. Leadership styles
  - 1. Coaching
  - 2. Motivating
  - 3. Empowering
  - 4. Situational leadership
- C. Effective communication skills
  - 1. Guide the team through change
  - 2. Successfully achieve a common goal

### **IV. Characteristics of a Productive Team**

- A. Interdependence
- B. Trust
- C. Communication
- D. Diversity

# Pathophysiology

## Description

Content focuses on the characteristics and manifestations of diseases caused by alterations or injury to the structure or function of the body. Concepts basic to pathophysiology as well as common disease conditions are studied and serve in understanding alterations that occur in the major body systems. Emphasis is placed on the image correlation with these pathologies. The in-depth study of pathophysiology allows the professional to communicate better with other health care professionals, including physicians and scientists, as well as with the patient, for the history and physical assessment.

## Objectives

1. Define terminology used in the study of disease.
2. Describe the general principles and mechanisms of disease.
3. Describe the physiological response in inflammation and cell injury due to pathological insult.
4. Differentiate between the processes of various types of cellular and tissue injury and adaptive mechanisms.
5. Describe the disorders of fluid and electrolyte balance.
6. Differentiate between the mechanisms of tissue repair and healing.
7. Identify common tests used to diagnose disease or injury.
8. Examine the role of nutrition and genetics in disorders.
9. Describe the common etiology, signs and symptoms, diagnostic tests, typical course and management of common diseases and disorders of body systems.
10. Discuss the common effects of aging on each of the body systems.



## **Content**

### **I. Concepts of Health and Disease Defined**

- A. Definition of health
- B. Disease terminology
- C. Influences on health and the development of disease

### **II. Alterations in Cell Function and Growth**

- A. Cell and tissue characteristics
- B. Cellular adaptation and injury
- C. Genetic and congenital disorders
- D. Alterations in cell differentiation: neoplasia
- E. Tissue repair and wound healing

### **III. Alterations in Body Defenses**

- A. Stress and adaption
- B. Alterations in temperature regulation
- C. Infectious processes
- D. Inflammation and repair
- E. The immune response
- F. Alterations in the immune response
- G. Acquired immunodeficiency syndrome (AIDS)
- H. White blood cell and lymphoproliferative disorders
- I. Alterations in hemostasis and blood coagulation

### **IV. Alterations in Oxygenation of Tissues**

- A. Composition of blood and blood formation
- B. The red blood cell and alterations in oxygen transport
- C. The circulatory system and control of blood flow
- D. Alterations in blood flow

- E. Control of arterial blood pressure
- F. Alterations in blood pressure
- G. Control of cardiac function
- H. Alterations in cardiac function
  1. Disorders of the pericardium
  2. Coronary artery disease
  3. Dysrhythmias and conduction disorders
  4. Disorders of the endocardium
  5. Valvular disease
  6. Cardiomyopathies
  7. Congenital heart disease
  8. Diagnosis and treatment
- I. Heart failure
- J. Circulatory shock
- K. Control of respiratory function

**V. Alterations in Respiratory Function**

- A. Respiratory infections
- B. Disorders of the pleura
- C. Obstructive lung disorders
- D. Interstitial lung disorders
- E. Pulmonary vascular disorders
- F. Cancer of the lung
- G. Ventilation disorders
- H. Respiratory failure
  - I. Diagnosis and treatment

**VI. Alterations in Body Fluids**

- A. Alterations in body fluids and electrolytes
- B. Alterations in the distribution of body fluids

- C. Alterations in acid-base balance
- D. Control of renal function
- E. Alterations in renal function
  1. Congenital disorders
  2. Urinary tract infections and pyelonephritis
  3. Obstructive disorders
  4. Disorders of the nephron and glomerulus
  5. Neoplasms
  6. Renal failure
  7. Diagnosis and treatment

**VII. Alterations in Reproductive Function**

- A. Structure and function of the reproductive system
- B. Alterations in the structure and function of the reproductive system
  1. Disorders of the testes and prostate
  2. Disorders of the uterus, ovaries and breasts
- C. Diagnosis and treatment

**VIII. Alterations in Endocrine Function, Metabolism**

- A. Mechanism of endocrine control
- B. Control of metabolism
- C. Alterations in endocrine control of growth and metabolism
- D. Control of diabetes
- E. Diagnosis and treatment

**IX. Alterations in GI Function**

- A. Control of gastrointestinal function
- B. Alterations of GI function
  1. Manifestations of GI tract disorders
  2. Disorders of the esophagus
  3. Disorders of the stomach
  4. Disorders of the small and large bowel
  5. Disorders of the peritoneum
  6. Malabsorption
- C. Alterations in function of the hepatobiliary system and pancreas

D. Diagnosis and treatment

**X. Alterations in Neuromuscular Function**

A. Properties of the nervous tissue

B. Control of neuromuscular and autonomic nervous system function

C. Development and segmental organization of the nervous system

D. Disorders of cerebral function

1. Increased cranial pressure
2. Infections
3. Seizures
4. Consciousness and unconsciousness
5. Organic brain syndrome

E. Alterations in motor function

1. Control of motor function
2. Alterations in cerebral circulation
3. Disorders of the myelin
4. Spinal cord injury
5. Alterations in neuromuscular function

F. Pain

1. Pain mechanisms and response
2. Pain disorders
3. Treatment for pain

G. Diagnosis and treatment

**XI. Alterations in Skeletal Support and Movement**

A. Structure and function of the skeletal system

B. Alterations in skeletal function: trauma and infection

1. Injury and trauma of musculoskeletal structures
2. Bone infections

C. Alterations in skeletal function

1. Arthritis
2. Congenital disorders
3. Metabolic bone disease
4. Neoplasms

D. Diagnosis and treatment



**XII. Alterations in Skin Function and Integrity**

**XIII. Alterations in Structure and Function Related to Aging**

A. Physiologic changes of aging

B. Functional considerations of aging

1. Incontinence
2. Instability and falls
3. Sensory and cognitive impairment
4. Depression
5. Dementia
6. Delirium

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# Patient Information Management

## Description

Patient information management is important because of the integral role the radiologic technologist has within the health care team. It is essential for the radiologic technologist to provide all members of the team with a thorough patient record to ensure quality patient care.

## Objectives:

1. Describe The Joint Commission standards and Health Insurance Portability and Accountability Act (HIPAA) regulations regarding the accountability and protection of patient information.
2. Evaluate the patient record to ensure The Joint Commission standards and HIPAA regulations are satisfied.
3. Explain the process by which imaging departments develop and revise policies and procedures to maintain compliance regarding patient information
4. Analyze the potential abuses in maintaining confidential patient information.

## **Content**

### **I. The Joint Commission Standards**

- A. Accountability for protecting patient information
  - 1. Information collection
  - 2. Information maintenance
  - 3. Use of personally identifiable health information
  - 4. Contractual agreements
  - 5. Demonstrating and monitoring compliance
  
- B. Consents
  - 1. Informed
    - a. Patient and provider elements
  - 2. Release of information
    - a. Purposes
    - b. Types of information released
    - c. Recipients of information
  
- C. Education regarding policies, rights and responsibilities
  - 1. Patient education
  - 2. Provider education

### **II. Health Insurance Portability and Accountability Act (HIPAA)**

- A. Evolution of HIPAA
  
- B. Impact on health care providers and personnel
  
- C. Disclosure
  
- D. State laws and regulations affecting the use of disclosure of health information
  
- E. Health Information Technology for Economic and Clinical Health (HITECH) Act

### **III. Protected Health Information**

- A. Information systems
  - 1. Hospital information system (HIS)
  - 2. Radiology information system (RIS)
  - 3. Picture archiving and communications system (PACS)
  
- B. Standards
  - 1. Digital imaging and communication in medicine (DICOM)
  - 2. Health level standards (HL7)
  
- C. Health information exchanges (HIE)
  
- D. Methods of obtaining patient health information
  - 1. Coding and standardization

- E. Physical or electronic health record content
  - 1. Elements of proper charting and documentation
  - 2. Legal ramifications of improper charting and documentation

#### **IV. Compliance**

- A. Accreditation
- B. Federal and state regulations
- C. Protected health information (PHI)
- D. Non-compliance issue

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# Pharmacology

## Description

An exploration of pharmacology is necessary to provide the student with comprehensive knowledge concerning drugs and their applications in medical imaging. Drug regulations, types of drugs and drug administration are included. Discussions integrate the selection of drugs with their appropriate use and possible effects.

## Objectives

1. Outline consumer safety and drug regulations.
2. Differentiate among various types of drugs and their proper application.
3. Administer drugs commonly used for medical imaging.
4. Assess various types of responses following drug administration.

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## **Content**

### **I. Consumer Safety and Drug Regulations**

- A. Federal drug laws
  - 1. 1906 Pure Food and Drug Act
  - 2. 1938 Federal Food, Drug and Cosmetic Act
  - 3. 1970 Controlled Substances Act
- B. State drug laws
- C. The Food and Drug Administration
- D. Drug Enforcement Administration
- E. Proper disposal procedures

### **II. Abbreviations and Systems of Measurement**

### **III. Drug Nomenclature and References**

- A. Classifications
- B. Identifying names
  - 1. Generic name
  - 2. Chemical name
  - 3. Trade name
  - 4. Official name (as it appears in the United States Pharmacopoeia - USP/National Formulary - NF)
- C. Legal terms referring to drugs
  - 1. Over-the-counter
  - 2. Legend (or prescription) drug
  - 3. Controlled substance
- D. Terms indicating drug actions
  - 1. Indications
  - 2. Actions
  - 3. Contraindications
  - 4. Cautions
  - 5. Side effects
  - 6. Adverse reactions
  - 7. Interactions
- E. Drug references
  - 1. Physicians' Desk Reference
  - 2. *United States Pharmacopoeia dispensing information*
  - 3. *American Hospital Formulary Service*
  - 4. *Compendium of Drug Therapy*

5. *Facts and Comparisons*
6. *American Hospital Formulary Service Drug Information*
7. *Mosby's GenRx*

#### **IV. Biopharmaceutics**

- A. Dosage forms
  1. Tablets
  2. Capsules
  3. Lozenges
  4. Compressed suppositories or inserts
  5. Injectables
  
- B. Pharmacokinetics
  1. Disintegration and dissolution
  2. Absorption
  3. Distribution
  4. Metabolism
  5. Excretion
  
- C. Other variables
  1. Age
    - a. Pediatric considerations
    - b. Geriatric considerations
  2. Weight
  3. Sex
  4. Psychological state
  5. Drug interactions
  6. Dosage
  7. Route
  
- D. Unexpected responses to drugs
  1. Teratogenic effect
  2. Tolerance
  3. Dependence
  4. Hypersensitivity
  5. Anaphylactic reaction

#### **V. Pharmacodynamics**

- A. Mechanisms of action
  1. Drug-receptor interactions
  2. Drug-enzyme interactions
  3. Nonspecific response relationships
  4. Drug response relationships
  
- B. Half-life
  1. Duration of drug effect

- C. Therapeutic index
- D. Adverse effects
- E. Drug-drug interactions

**VI. Safe Dosage Preparation**

- A. Calculation guidelines
- B. Age-appropriate dosage

**VII. Responsibilities and Principles of Drug Administration**

- A. Responsible drug administration
  - 1. Informed consent
  - 2. Preprocedural/postprocedural assessment
  - 3. Evaluation of laboratory values
- B. Medication error avoidance

**VIII. Administration Routes and Techniques**

- A. Gastrointestinal (GI)
  - 1. Oral
  - 2. Nasogastric tube
  - 3. Gastric tube
  - 4. Rectal
- B. Parenteral
  - 1. Buccal
  - 2. Transcutaneous
  - 3. Inhalation therapy
  - 4. Injections
  - 5. Topical
  - 6. Application to mucous membranes
- C. Appropriate documentation of administration and patient outcomes
  - 1. Dose
  - 4. Time
  - 5. Route
  - 6. Location of injections
  - 7. Sign or initial record
  - 8. Documentation involving narcotics and any medications

**IX. Frequently Used Drug Categories**

- A. Basic drug categories relevant to radiography as described in the Radiography Curriculum Guidelines



- B. Drug categories relevant to patient care that go beyond radiography applications
  - 1. Adrenergic blocking agents
  - 2. Antimicrobials
  - 3. Antifungals
  - 4. Antivirals
  - 5. Anticholinergics
  - 6. Anticonvulsants
  - 7. Antiperistaltics
  - 8. Antipsychotics
  - 9. Antipyretics
  - 10. Antitussives
  - 11. Barbiturates
  - 12. Cardiac depressants/stimulants
  - 13. Emetics
  - 14. Hypoglycemics
  - 15. Opioids/opioid antagonists
  - 16. Radiopharmaceuticals
  - 17. Musculoskeletal relaxants
  - 18. Stimulants/tranquilizers

**X. Contrast Media**

- A. Routes of administration
  - 1. Parenteral (intravascular)
  - 2. Enteral
- B. Pharmacology of parenteral contrast media
  - 1. Categories
    - a. Ionic
    - b. Non-ionic
    - c. Low osmolar
    - d. Paramagnetic
    - e. Echogenic
  - 2. Distribution
  - 3. Excretion
- C. Adverse pharmacodynamics of parenteral contrast media
  - 1. Osmolality
  - 2. Chelation
  - 3. Anticoagulation
  - 4. Autoimmune response
  - 5. Nephrotoxicity
  - 6. Neurotoxicity
  - 7. Thyrotoxicity
  - 8. Drug interactions

- D. Administration and dosage
- E. Pharmacology of enteral contrast agents
  - 1. Barium sulfate
  - 2. Water-soluble iodinated
  - 3. Methylcellulose
  - 4. MR contrast agents
- F. Postprocedure instructions

**XI. Adverse Reactions**

- A. Patient assessment
  - 1. Screening
  - 2. Monitoring
- B. Patient treatment
  - 1. Department protocol for each pharmacologic agent
  - 2. Technologist responsibilities
  - 3. Symptoms and recommended response
    - a. Minor reaction
    - b. Moderate reaction
    - c. Severe reaction
    - d. Extravasation/infiltration

# Quality Management

## Description

Quality management (QM) is important to ensure the proper functioning of equipment and compliance with government and accreditation standards. Thus, technologists should have an understanding of the activities and their role in the QM process. This content is designed to expand the QM skills of the technologist to include digital imaging systems and the application of QM principles in an imaging department.

## Objectives

1. Differentiate between quality management (QM), quality assurance (QA) and quality control (QC).
2. Apply QM principles to a given scenario.
3. Analyze collected QM data and make appropriate recommendations.
4. Analyze the benefits of a QM program to the patient and to the department.
5. Develop a QM plan to collect data for digital imaging equipment.

## **Content**

### **I. Definitions**

- A. Quality management (QM)
- B. Quality assurance (QA)
- C. Quality control (QC)

### **II. Concepts and Principles of QM**

- A. Philosophical basis
- B. QM problem-solving strategies
- C. Tools for problem identification and analysis

### **III. Collection and Analysis of QA Data**

- A. Development of indicators
- B. Data collection methods
- C. Assessment of outcomes
- D. Standards for quality

### **IV. Benefits**

- A. Internal customers
- B. External customers

### **V. QM Requirements for Computed Radiography/Digital Radiography/PACS**

- A. Initial acceptance testing
- B. System reader preventive maintenance (PM)
- C. Plate maintenance
- D. Uniformity of processing codes
- E. System detectors
- F. Image quality
- G. Image output
- H. Repeat/reject analysis



# Research Methods and Information Literacy

## Description

Research methods and information literacy are important because the health care profession is continually changing, which requires the radiologic technologist to possess new knowledge to function competently. The radiologic technologist should contribute to the body of knowledge and be able to effectively analyze resources to promote growth in the profession. The attitude of life-long learning enables the radiologic technologist to stay in step with the current health care environment and be prepared to help foster the future and increase awareness of the profession in the global community. This content is geared to increase and disseminate intellectual inquiry, information literacy and the use of scholarly research methods.

## Objectives

1. Analyze research articles to determine the accuracy and validity of findings.
2. Integrate information literacy concepts into a research project.
3. Critique research projects to determine appropriateness and usefulness to the profession.

## **Content**

### **I. Analysis of Research Articles**

- A. Assessing appropriateness of article for source material
  - 1. Scholarly (peer-reviewed) publications
  - 2. News magazines, other non-peer-reviewed
  
- B. Assessing quality of information
  - 1. Research design
  - 2. Research bias
  - 3. Study validity
  
- C. Assessing value of article
  - 1. Application for future research and recommendations
  - 2. Implications for professional practice

### **II. Information Literacy Concepts**

- A. Research quality
  - 1. Technical accuracy
  - 2. Reader comprehension
  - 3. Scholarly
  - 4. Relevance to professional practice
  - 5. Effectiveness of writing style
  - 6. Appropriateness of form and style
  
- B. Systematic literature analysis
  - 1. Determining sources of information
  - 2. Using information search strategies
  - 3. Assessing value and appropriateness of source material
  
- C. Paper organization
  - 1. Appropriate title
  - 2. Title page
  - 3. Abstract
  - 4. Introduction
  - 5. Definition of terms
  - 6. Literature review
  - 7. Research design or methodology
  - 8. Hypothesis or purpose of research
  - 9. Results or analysis
  - 10. Conclusions, discussions and recommendations

### **III. Types of Research Projects**

- A. Literature review
  
  
- B. Survey

- C. Descriptive/technical
- D. Case studies
- E. Posters
- F. Qualitative (observation or interview)

#### **IV. Preparing a Research Project**

- A. Topic selection
  - 1. Analysis of current literature on topic
  - 2. Identification of clinical practice issues
- B. Information search strategies
  - 1. Identifying information sources
  - 2. Types of searches (manual, electronic – Ovid, PubMed, etc.)
- C. Ethical principles and legal consideration
- D. Review of the literature
  - 1. Analysis of source material
  - 2. Integration of material into project
- E. Research design and data collection
  - 1. Qualitative
  - 2. Quantitative
  - 3. Mixed methods
- F. Data Analysis
  - 1. Terms (sensitivity, specificity, predictor values, false-positive, false-negative, etc.)
  - 2. Statistical methods – determine significance of data
  - 3. Qualitative methods
  - 4. Triangulation of multiple data sources
- G. Dissemination of findings
  - 1. Format
    - a. Abstract
    - b. Article
    - c. Poster
    - d. PowerPoint presentation
    - e. Others
  - 2. Reference formats, (e.g. American Medical Association or AMA, American Psychological Association or APA, etc.)
  - 3. Illustrations (images, charts, etc.)
- H. Preparation of draft and revisions of project

- I. Submission for publication
  - 1. Peer-reviewed
  - 2. Other (editorial, columns, etc.)

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## Optional Content

Content in this section will assist program planners wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of a given program and/or local employment market.

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# Educational Principles for Technologists

## Description

Content is designed to impart an understanding of strategies and techniques for developing skills as an effective facilitator of learning in the clinical setting.

## Objectives

- ◆ Identify common learning opportunities in the direct patient care clinical setting.
- ◆ Identify typical situations in the clinical setting in which technologists assume the role of a facilitator of learning.
- ◆ Differentiate training events from educational events in the clinical setting.
- ◆ Describe how the information processing theory influences the planning of an instructional event.
- ◆ List typical characteristics of adult learners.
- ◆ Employ an instructional design model in the development of an instructional event.
- ◆ Employ Gagne's nine events of instruction in the delivery of an instructional experience.

## **Content**

### **I. Learning Events in the Clinical Setting**

- A. Formal vs. informal
  
- B. Synchronous vs. asynchronous

### **II. Training vs. Education**

- A. Task oriented
  
- B. Personal and professional growth oriented

### **III. Technologist in the Role of Facilitator of Learning**

- A. Formal and informal
  
- B. Patient interactions
  
- C. Peer instruction
  
- D. Interactions with other agents within the clinical setting
  
- E. Community service

### **IV. Information Processing Theory**

- A. Basic principles
  
- B. Applications in instruction

### **V. Adult Learners**

- A. Knowles' andragogy
  
- B. Characteristics
  1. Want to be treated with respect
  2. Have immediate learning needs
  3. Have a low tolerance for busy work
  4. Have useful past experience
  5. Seek activities that build on prior skills and knowledge
  6. Are intrinsically motivated
  7. Appreciate active/lively learning events

### **VI. Principles of Instructional Design**

- A. ADDIE Model
  1. Analyze
  2. Design
  3. Develop
  4. Implement
  5. Evaluation

- B. Alternative Models
  - 1. Dick and Carey Model
  - 2. Problem-based Learning
- C. Application in the clinical setting

## **VII. Events of Instruction**

- A. Gagne's Nine Events of Instruction
  - 1. Gain attention
  - 2. Activating motivation
  - 3. Stimulating recall of prerequisite learning
  - 4. Presenting stimulus material
  - 5. Providing learning guidance
  - 6. Eliciting the performance
  - 7. Providing feedback
  - 8. Assessing the learner's performance
  - 9. Promoting retention and transfer
- B. Application in the clinical setting
- C. Value of personal assessment and reflection following an instructional event



# Health Care Informatics

## Description

Medical informatics is an important part of the medical environment; therefore, health care providers must have an understanding of how computers are used in health care delivery. This content is designed to provide an exploration of information technology as it applies to health care and health care organizations. An overview of how information is captured, converted, stored and ultimately used within the health care system is provided.

## Objectives

- ◆ Describe the role of technology in health care.
- ◆ Explain the ethical concerns related to health care informatics.
- ◆ Examine the impact of regulations, laws and standards related to informatics on health care delivery.
- ◆ Evaluate decision-making strategies used in informatics.
- ◆ Compare and contrast different informatics applications in health care.

## **Content**

### **I. Health Care Informatics**

- A. Definition
- B. History
- C. Theories
- D. Databases
- E. Ethics

### **II. Regulations, Laws and Standards**

- A. Licensure/certification
- B. Accreditation
- C. National and international standards
- D. Federal laws

### **III. Decision-making**

- A. Administrative
- B. Clinical
- C. Evidence-based medicine

### **IV. Healthcare Informatics Applications**

- A. Electronic health records
- B. Patient care systems
- C. Patient monitoring systems
- D. Radiology imaging systems

### **V. Future Trends**

## Appendix

This section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. The content in this section is intended to aid technologists in career planning and program managers in the development of preassessment tools for candidate selection.

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## Clinical Practice

### Description

Content and clinical practice experiences should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of radiologic procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient preparatory to, during and following the radiologic procedure.

### Objectives

- || Exercise the priorities required in daily clinical practice.
- || Execute medical imaging procedures under the appropriate level of supervision.
- || Adhere to team practice concepts that focus on organizational theories, roles of team members and conflict resolution.
- || Adapt to changes and varying clinical situations.
- || Describe the role of health care team members in responding/reacting to a local or national emergency.
- || Provide patient-centered clinically effective care for all patients regardless of age, gender, disability, special needs, ethnicity or culture.
- || Integrate the use of appropriate and effective written, oral and nonverbal communication with patients, the public and members of the health care team in the clinical setting.
- || Integrate appropriate personal and professional values into clinical practice.
- || Recognize the influence of professional values on patient care.
- || Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- || Use patient and family education strategies appropriate to the comprehension level of the patient/family.
- || Provide desired psychosocial support to the patient and family.
- || Demonstrate competent assessment skills through effective management of the patient's physical and mental status.
- || Respond appropriately to medical emergencies.
- || Examine demographic factors that influence patient compliance with medical care.
- || Adapt procedures to meet age-specific, disease-specific and cultural needs of patients.
- || Assess the patient and record clinical history.
- || Demonstrate basic life support procedures.
- || Use appropriate charting methods.
- || Recognize life-threatening electrocardiogram (ECG) tracing.
- || Apply standard and transmission-based precautions.
- || Apply the appropriate medical asepsis and sterile technique.



- || Demonstrate competency in the principles of radiation protection standards.
- || Apply the principles of total quality management.
- || Report equipment malfunctions.
- || Examine procedure orders for accuracy and make corrective actions when applicable.
- || Demonstrate safe, ethical and legal practices.
- || Integrate the radiographer's practice standards into clinical practice setting.
- || Maintain patient confidentiality standards and meet HIPAA requirements.
- || Demonstrate the principles of transferring, positioning and immobilizing patients.
- || Comply with departmental and institutional response to emergencies, disasters and accidents.
- || Differentiate between emergency and non-emergency procedures.
- || Adhere to national, institutional and departmental standards, policies and procedures regarding care of patients, providing radiologic procedures and reducing medical errors.
- || Select technical factors to produce quality diagnostic images with the lowest radiation exposure possible.
- || Critique images for appropriate anatomy, image quality and patient identification.
- || Determine corrective measures to improve inadequate images.

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## Digital Image Acquisition and Display

### Description

Content imparts an understanding of the components, principles and operation of digital imaging systems found in diagnostic radiology. Factors that impact image acquisition, display, archiving and retrieval are discussed. Principles of digital system quality assurance and maintenance are presented.

**Special Note:** Digital imaging is a rapidly evolving technology. Every effort has been made to provide a curriculum outline that reflects, as accurately as possible, the state of the art of this discipline as of publication. Educators are encouraged to modify this outline with up-to-date information as it becomes available from vendors, clinical sites, textbooks, and technical representatives.

### Objectives

- || Define terminology associated with digital imaging systems.
- || Describe the various types of digital receptors.
- || Describe the response of digital detectors to exposure variations.
- || Compare the advantages and limits of each receptor type.
- || Evaluate the spatial resolution and dose effectiveness for digital radiography detectors.
- || Describe the histogram and the process or histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
- || Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
- || Describe the response of PSP systems to background and scatter radiation.
- || Use appropriate means of scatter control.
- || Avoid grid use errors associated with grid cutoff and Moiré effect.
- || Identify common limitations and technical problems encountered when using PSP systems.
- || Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
- || Associate impact of image processing parameters to the image appearance.
- || Apply the fundamental principles to digital detectors.
- || Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
- || Describe the conditions that cause quantum mottle in a digital image.
- || Formulate a procedure or process to minimize histogram analysis and rescaling errors.
- || Examine the potential impact of digital radiographic systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
- || Describe picture archival and communications system (PACS) and its function.
- || Identify components of a PACS.
- || Define digital imaging and communications in medicine (DICOM).
- || Describe HIPAA concerns with electronic information.
- || Identify common problems associated with retrieving/viewing images within a PACS.



## Ethics and Law in the Radiologic Sciences

### Description

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

### Objectives

- || Discuss the origins of medical ethics.
- || Apply medical/professional ethics in the context of a broader societal ethic.
- || Explain the role of ethical behavior in health care delivery.
- || Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
- || Identify legal and professional standards and relate each to practice in health professions.
- || Identify specific situations and conditions that give rise to ethical dilemmas in health care.
- || Explain select concepts embodied in the principles of patients' rights, the doctrine of informed (patient) consent and other issues related to patients' rights.
- || Explain the legal implications of professional liability, malpractice, professional negligence and other legal doctrines applicable to professional practice.
- || Describe the importance of accurate, complete and correct methods of documentation as a legal/ethical imperative.
- || Explore theoretical situations and questions relating to the ethics of care and health care delivery.
- || Explain legal terms, principles, doctrines and laws specific to the radiologic sciences.
- || Outline the conditions necessary for a valid malpractice claim.
- || Describe institutional and professional liability protection typically available to the radiographer.
- || Describe the components and implications of informed consent.
- || Identify standards for disclosure relative to informed consent.
- || Describe how consent forms are used relative to specific radiographic procedures.
- || Differentiate between civil and criminal liability.
- || Define tort and explain the differences between intentional and unintentional torts.

## Human Structure and Function

### Description

Content establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems are described and discussed. The fundamentals of sectional anatomy relative to routine radiography are addressed.

### Objectives

- || Discuss the basics of anatomical nomenclature.
- || Describe the chemical composition of the human body.
- || Identify cell structure and elements of genetic control.
- || Explain the essentials of human metabolism.
- || Describe the types and functions of human tissues.
- || Classify tissue types, describe the functional characteristics of each and give examples of their location within the human body.
- || Describe the composition and characteristics of bone.
- || Identify and locate the bones of the human skeleton.
- || Identify bony processes and depressions found on the human skeleton.
- || Describe articulations of the axial and appendicular skeleton.
- || Differentiate the primary and secondary curves of the spine.
- || Summarize the functions of the skeletal system.
- || Label different types of articulations.
- || Compare the types, locations and movements permitted by the different types of articulations.
- || Examine how muscle is organized at the gross and microscopic levels.
- || Differentiate between the structures of each type of muscle tissue.
- || State the function of each type of muscle tissue.
- || Name and locate the major muscles of the skeleton.
- || Differentiate between the structure and function of different types of nerve cells.
- || State the structure of the brain and the relationship of its component parts.
- || Describe brain functions.
- || List the meninges and describe the function of each.
- || Outline how cerebrospinal fluid forms, circulates and functions.
- || Describe the structure and function of the spinal cord.
- || Determine the distribution and function of cranial and spinal nerves.
- || Summarize the structure and function of components that comprise the autonomic nervous system.
- || Describe the structures and functions of the components that comprise the human eye and ear.
- || List the component body parts involved in the senses of smell and taste.
- || List the somatic senses.
- || Define endocrine.



- || Describe the characteristics and functions of the components that comprise the endocrine system.
- || Describe the hard and soft palates.
- || Describe the structure and function of the tongue.
- || Identify the structure, function and locations of the salivary glands.
- || Describe the composition and characteristics of the primary organs of the digestive system.
- || Describe the function(s) of each primary organ of the digestive system.
- || Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
- || Differentiate between peritoneum, omentum and mesentery.
- || List and label the accessory organs of the digestive system and describe their function.
- || Identify the secretions and function of each accessory organ of the digestive system.
- || Explain the purpose of digestion.
- || List the digestive processes that occur in the body.
- || Describe the composition and characteristics of blood.
- || List the types of blood cells and state their functions.
- || Differentiate between blood plasma and serum.
- || Outline the clotting mechanism.
- || List the blood types.
- || Explain the term Rh factor.
- || Explain the antigen/antibody relationship and its use in blood typing.
- || Label the parts of the human heart.
- || Describe the flow of blood through the body and identify the main vessels.
- || Describe the structure and function of arteries, veins and capillaries.
- || Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
- || Outline the major pathways of lymphatic circulation.
- || Correlate cardiac electrophysiology to a normal ECG tracing.
- || Differentiate between nonspecific defenses and specific immunity.
- || Explain antibody production and function.
- || List the different types and functions of T- and B-cells and explain their functions.
- || Label the components of the respiratory system.
- || Describe the physiology and regulation of respiration.
- || Label the parts of the kidneys, ureters, bladder and urethra.
- || Describe the function of each organ of the urinary system.
- || Describe the composition and formation of urine.
- || Explain micturition.
- || Label the anatomy of the male and female reproductive organs.
- || Analyze the function of each of the male and female reproductive organs.
- || Identify major sectional anatomical structures found within the head/neck, thorax and abdomen.

## Introduction to Computed Tomography

### Description

Content is designed to provide entry-level radiography students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

### Objectives

- || Describe the components of the CT imaging system.
- || Explain the functions of collimators in CT.
- || List the CT computer data processing steps.
- || Define algorithm and explain its impact on image scan factors and reconstruction.
- || Define raw data and image data.
- || Describe the following terms in relation to the CT data acquisition process:
  - || Pixel.
  - || Matrix.
  - || Voxel.
  - || Linear attenuation coefficient.
  - || CT/Hounsfield number.
  - || Partial volume averaging.
  - || Window width (ww) and window level (wl).
  - || Spatial resolution.
  - || Contrast resolution.
  - || Noise.
  - || Annotation.
  - || Region of interest (ROI).
- || Name the common controls found on CT operator consoles and describe how and why each is used.
- || Identify the types and appearance of artifacts most commonly affecting CT images.
- || Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.
- || Describe the general purpose of commonly performed CT studies.
- || Discuss general radiation safety and protection practices associated with examinations in CT.

## Medical Terminology

### Description

Content provides an introduction to the origins of medical terminology. A word-building system is introduced and abbreviations and symbols are discussed. Also introduced is an orientation to understanding radiographic orders and diagnostic report interpretation. Related terminology is addressed.

### Objectives

- || Apply the word-building process.
- || Interpret medical abbreviations and symbols.
- || Critique orders, requests and diagnostic reports.
- || Define medical imaging and radiation oncology terms.
- || Translate medical terms, abbreviations and symbols into common language from a medical report.

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## Pathophysiology

### Description

Content is designed to introduce concepts related to the disease process. An emphasis on etiological considerations, neoplasia, and associated diseases in the radiation therapy patient should be presented.

### Objectives

- || Describe the physiological response in inflammation and cell injury due to pathological insult.
- || Assess the predictive factors, including genetics, lifestyles, age and environment as they influence the development of cancer and associated diseases.
- || Compare the body's response to hereditary, lifestyle, age and environmental factors.
- || Given a specific oncologic-related disease, determine probable diagnostic, prognostic, staging, grading and the rationale for the appropriate therapeutic pathway.
- || Given the histology of a neoplasm, determine the tumor characteristics.
- || Given a common disease, anticipate the effects of the disease on the oncologic patient.

## Patient Care in Radiologic Sciences

### Description

Content is designed to provide the basic concepts of patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the radiographer in patient education is identified.

### Objectives

- || Identify the responsibilities of the health care facility and members of the health care team.
- || List the general responsibilities of the radiographer.
- || Describe the practice standards for the radiographer as defined by the ASRT and state licensure.
- || Differentiate between culture and ethnicity.
- || Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- || Explain perceptions of dying and death from the viewpoint of both patient and radiographer.
- || Describe the characteristics of each stage of grief.
- || Identify methods for determining the correct patient for a given procedure.
- || Explain the use of various communication devices and systems.
- || Explain specific aspects of a radiographic procedure to the patient.
- || Demonstrate correct principles of body mechanics applicable to patient care.
- || Demonstrate techniques for specific types of patient transfer.
- || Demonstrate select procedures to turn patients with various health conditions.
- || Describe select immobilization techniques for various types of procedures and patient conditions.
- || Describe specific patient safety measures and concerns.
- || Explain the purpose, legal considerations and procedures for incident reporting.
- || Describe methods to evaluate patient physical status.
- || List the information to be collected prior to a patient examination.
- || Describe vital signs and lab values used to assess patient condition, including sites for assessment and normal values.
- || Define terms related to infection control.
- || Describe the importance of standard precautions and isolation procedures, including sources and modes of transmission of infection and disease and institutional control procedures.
- || Identify symptoms related to specific emergency situations.
- || Describe the institution's emergency medical code system and the role of the student during a medical emergency.
- || Explain the age-specific considerations necessary when performing radiographic procedures.
- || Describe appropriate procedures for management of various types of trauma situations.

- || Describe the symptoms and medical interventions for a patient with a contrast agent reaction.
- || Explain the role of the radiographer in patient education.
- || Describe the patient preparation for contrast studies.
- || Identify specific types of tubes, lines, catheters and collection devices.
- || Outline the steps in the operation and maintenance of suction equipment.
- || Outline the steps in the operation and maintenance of oxygen equipment and demonstrate proper use.
- || Demonstrate competency in basic life support (BLS).
- || Describe the steps in performing various mobile procedures.
- || Describe the special problems faced in performing procedures on a patient with a tracheotomy and specific tubes, drains and catheters.
- || Describe the procedure for producing diagnostic images in the surgical suite.
- || Explain the appropriate radiation protection required when performing mobile/surgical radiography.

ASRT



## Pharmacology and Venipuncture

### Description

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

### Objectives

- || Distinguish among the chemical, generic and trade names for drugs in general.
- || Describe pharmacokinetic and pharmacodynamic principles of drugs.
- || Explain the uses and impact of drug categories on the patient.
- || Define the categories of contrast agents and give specific examples for each category.
- || Explain the pharmacology of contrast agents.
- || Describe methods and techniques for administering various types of contrast agents.
- || Identify and describe the routes of drug administration.
- || Demonstrate appropriate venipuncture technique.
- || Differentiate between the two major sites of intravenous drug administration.
- || Identify, describe and document complications associated with venipuncture and appropriate actions to resolve these complications.
- || Discuss the various elements of initiating and discontinuing intravenous access.
- || Differentiate and document dose calculations for adult and pediatric patients.
- || Prepare for injection of contrast agents/intravenous medications using aseptic technique.
- || Explain the current legal status and professional liability issues of the radiographer's role in contrast and/or drug administration.

## Radiation Biology

### Description

Content provides an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

### Objectives

- || Differentiate between ionic and covalent molecular bonds.
- || Describe principles of cellular biology.
- || Identify sources of electromagnetic and particulate ionizing radiations.
- || Discriminate between direct and indirect ionizing radiation.
- || Discriminate between the direct and indirect effects of radiation.
- || Identify sources of radiation exposure.
- || Describe radiation-induced chemical reactions and potential biologic damage.
- || Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
- || Identify methods to measure radiation response.
- || Describe physical, chemical and biologic factors influencing radiation response of cells and tissues.
- || Explain factors influencing radiosensitivity.
- || Recognize the clinical significance of lethal dose (LD).
- || Identify specific cells from most radiosensitive to least radiosensitive.
- || Employ dose response curves to study the relationship between radiation dose levels and the degree of biologic response.
- || Examine effects of limited vs. total body exposure.
- || Relate short-term and long-term effects as a consequence of high and low radiation doses.
- || Differentiate between somatic and genetic radiation effects and discuss specific diseases or syndromes associated with them.
- || Discuss stochastic (probabilistic) and nonstochastic (deterministic) effects.
- || Discuss embryo and fetal effects of radiation exposure.
- || Discuss risk estimates for radiation-induced malignancies.
- || Discuss acute radiation syndromes.



## Radiation Physics

### Description

Content is designed to establish a basic knowledge of physics pertinent to developing an understanding of radiations used in the clinical setting. Fundamental physical units, measurements, principles, atomic structure and types of radiation are emphasized. Also presented are the fundamentals of x-ray generating equipment, x-ray production and its interaction with matter.

### Objectives

- || Define the fundamental units of the English, metric and Syst me International d' Unites (SI) systems.
- || Calculate various unit conversions.
- || Demonstrate applications of the general principles that relate to inertia, work, energy and momentum.
- || Describe Bohr's theory of atomic structure.
- || Compare the characteristics and functions of a proton, neutron and electron.
- || Discuss the energy levels of the atom.
- || Define the terms relating to atomic nomenclature.
- || Compare covalent bonding and ionic bonding.
- || Describe the process of ionization.
- || Differentiate between the characteristics of a mixture, substance and element.
- || Classify the characteristics of an element using the periodic table.
- || Compare the characteristics of a molecule and compound.
- || Describe the nature of light.
- || Explain the relationship between wavelength, frequency and velocity.
- || Differentiate between the radiations of the electromagnetic (EM) spectrum.
- || Explain the relationship of energy and frequency to Planck's constant.
- || Distinguish between electrical charge and electrical field.
- || Describe the methods of electrification.
- || Explain the laws of electrostatics and their application.
- || Describe the properties and laws of magnetism.
- || Explain the electronic spin of an element to its potential magnetic properties.
- || Describe the principle of magnetic induction.
- || Define potential difference, current, resistance, circuit and electric power.
- || Compare the characteristics of direct and alternating currents.
- || Compare electrical measuring devices.
- || Discuss electrical protective devices.
- || Discuss the interaction between electric and magnetic fields.
- || Describe the characteristics and functions of a cathode and rotating anode.
- || Describe the construction and function of tube housing.
- || Identify the parts of an x-ray tube.
- || Determine heat units and cooling characteristics of x-ray tube housings.

- || Propose methods to extend tube life.
- || Discuss application and components of automatic exposure devices.
- || State the principles of x-ray production.
- || Compare the production of bremsstrahlung with the production of characteristic radiations.
- || Compare various photon interactions in terms of description of interaction, relation to atomic number and applications.
- || Discuss relationships of wavelength and frequency to beam characteristics.
- || Define units of radiation measurement and provide an example of its application.

ASRT



## Radiation Protection

### Description

Content is designed to present an overview of the principles of radiation protection, including the responsibilities of the radiographer for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

### Objectives

- || Identify and justify the need to minimize unnecessary radiation exposure of humans.
- || Distinguish between somatic and genetic radiation effects.
- || Differentiate between the stochastic (probabilistic) and nonstochastic (deterministic) effects of radiation exposure.
- || Explain the objectives of a radiation protection program.
- || Define radiation and radioactivity units of measurement.
- || Identify effective dose limits (EDL) for occupational and nonoccupational radiation exposure.
- || Describe the ALARA concept.
- || Identify the basis for occupational exposure limits.
- || Distinguish between perceived risk and comparable risk.
- || Describe the concept of the negligible individual dose (NID).
- || Identify ionizing radiation sources from natural and man-made sources.
- || Comply with legal and ethical radiation protection responsibilities of radiation workers.
- || Describe the relationship between irradiated area and effective dose.
- || Describe the theory and operation of radiation detection devices.
- || Identify appropriate applications and limitations for each radiation detection device.
- || Describe how isoexposure curves are used for radiation protection.
- || Identify performance standards for beam-limiting devices.
- || Describe procedures used to verify performance standards for equipment and indicate the potential consequences if the performance standards fail.
- || Describe the operation of various interlocking systems for equipment and indicate potential consequences of interlock system failure.
- || Identify conditions and locations evaluated in an area survey for radiation protection.
- || Distinguish between controlled and non-controlled areas and list acceptable exposure levels.
- || Describe "Radiation Area" signs and identify appropriate placement sites.
- || Describe the function of federal, state and local regulations governing radiation protection practices.
- || Describe the requirements for and responsibilities of a radiation safety officer.
- || Express the need and importance of personnel monitoring for radiation workers.
- || Describe personnel monitoring devices, including applications, advantages and limitations for each device.
- || Interpret personnel monitoring reports.

- || Compare values for individual effective dose limits for occupational radiation exposures (annual and lifetime).
- || Identify anatomical structures that are considered critical for potential late effects of whole body irradiation exposure.
- || Identify effective dose limits for the embryo and fetus in occupationally exposed women.
- || Distinguish between primary and secondary radiation barriers.
- || Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
- || Perform calculations of exposure with varying time, distance and shielding.
- || Discuss the relationship between workload, energy, half-value layer (HVL), tenth-value layer (TVL), use factor and shielding design.
- || Identify emergency procedures to be followed during failures of x-ray equipment.
- || Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
- || Explain the relationship of beam-limiting devices to patient radiation protection.
- || Discuss added and inherent filtration in terms of the effect on patient dosage.
- || Explain the purpose and importance of patient shielding.
- || Identify various types of patient shielding and state the advantages and disadvantages of each type.
- || Use the appropriate method of shielding for a given radiographic procedure.
- || Explain the relationship of exposure factors to patient dosage.
- || Explain how patient position affects dose to radiosensitive organs.
- || Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
- || Select the immobilization techniques used to eliminate voluntary motion.
- || Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
- || Apply safety factors for the patient, health care personnel and family members in the room during radiographic procedures.



## Sectional Anatomy

### Description

Content will introduce students to medical imaging methods currently used in the field of radiation therapy. Students will identify normal anatomical structures via a variety of imaging formats. Basic anatomical relationships will be compared using topographical and cross-sectional images.

### Objectives

- || Relate the importance of imaging with computed tomography, magnetic resonance and PET-CT in radiation therapy.
- || Differentiate between sagittal, coronal and axial planes of the body.
- || Review the principles of imaging for imaging modalities using relevant terminology.
- || Compare the imaging modalities for application to radiation therapy.
- || Identify normal anatomical structures on sectional images.
- || Identify topographic anatomy used to locate underlying internal structures.

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# Degree Requirement & Employment Opportunity in Radiologic Science

RICHARD H WEENING, PhD, MIPP, R.T.(R)(CT)(MR), FAEIRS

**Objective** *To estimate the short-term effect of increasing the minimum education requirement for primary certification examination eligibility on employment opportunities in the radiologic sciences in the United States.*

**Methods** *Data was gathered from the websites of academic institutions, accrediting agencies, and certification bodies to determine the percentages of education programs that offer radiologic technology students certificates, associate degrees, bachelor's degrees, or master's degrees.*

**Results** *Approximately one-third of radiologic science education programs currently award certificates to their graduates.*

**Discussion** *Some certificate programs appear to be reacting slowly to the increasing of the minimum education requirement. In addition, there appears to be some recent cutbacks in the total number of professional education programs. Perhaps unfortunately, the time frame in which many education programs have been attempting to transition to award students an associate degree upon program completion has coincided with the recent period of global economic turmoil.*

**Conclusion** *The short-term effect of increasing the minimum education requirement on radiologic science employment opportunities could be large and non-negligible. Thus, employment opportunities for imaging professionals could grow faster than currently projected, as the supply of graduates meeting the increased minimum education requirement of an associate degree could be limited in the short term.*

In July 2009, the American Registry of Radiologic Technologists (ARRT) Board of Trustees approved the associate degree as the minimum education requirement for primary certification examination applicants in radiography, nuclear medicine, and radiation therapy, as well as for primary pathway certification examination applicants in magnetic resonance (MR) imaging and ultrasonography, beginning January 1, 2015. The new education requirement states that all candidates applying for primary examination certification must have earned an associate, bachelor's, or graduate degree from a mechanism acceptable to the ARRT beginning in 2015. Students who graduate from an ARRT-recognized education program by December 31, 2014, are exempt from the new degree requirement.

The required academic degree does not need to be in the radiologic sciences. The degree may be earned before entering a recognized program or after graduation from the program, or it may be awarded by the program, but the degree must be awarded before the applicant is granted eligibility to take an ARRT primary certification examination.<sup>1</sup>

Requiring an associate degree for primary examination eligibility is the second ARRT-enacted degree requirement. In 2005, the Registry made the bachelor's degree the minimum degree necessary to attempt the registered radiologist assistant (R.R.A.) certification examination.<sup>2</sup> As with the 2015 mandate, the required bachelor's or graduate degree does not need to be awarded by the R.R.A. education program; however, all R.R.A. programs currently award a bachelor's or master's degree to their students upon graduation.

In addition to the associate degree requirement, the ARRT Board of Trustees developed education requirements for postprimary certification examination eligibility effective January 1, 2016. These structured education requirements are intended to address cognitive learning and supplement the clinical experience requirements already in existence for postprimary ARRT certification examinations. To meet the new requirements, technologists can graduate from a traditional postprimary education program or use qualifying continuing education activities.<sup>3</sup>

The Nuclear Medicine Technology Certification Board (NMTCB) and the Medical Dosimetrist

Certification Board (MDCB) are making other important changes to education requirements for certification examination eligibility.<sup>4,5</sup> New NMTCB eligibility requirements take effect on January 1, 2016, and dictate that only individuals who graduate from programatically accredited nuclear medicine technology programs are eligible for the entry-level certification examination.<sup>4</sup> In the United States, the NMTCB recognizes the Joint Review Committee on Educational Programs in Nuclear Medicine Technology (JRCNMT) as the programmatic accrediting agency.

For medical dosimetry, the MDCB has indicated that several changes to its certification examination eligibility policy are coming.<sup>5</sup> However, effective 2017, only 1 education standard will exist for MDCB certification examination applicants: All candidates must have a bachelor of science degree and they must have graduated from a medical dosimetry program accredited by the Joint Review Committee on Education in Radiologic Technology (JRCERT).

With the upcoming changes in education requirements for entry into or advancement in the radiologic sciences, 2 questions arise:

- What is the current state of academic degree offerings from radiologic science education programs?
- How much will increasing the minimum education requirement affect employment opportunities in the United States in the short term?

Although the first question can be answered relatively straightforwardly, a precise answer to the second question is more difficult to determine because of the many factors involved in projecting employment opportunities. However, answering the second question could affect not only education programs, but also all radiologic science employees and employers in professional and economic ways.

### Literature Review

The Bureau of Labor Statistics (BLS) of the U.S. Department of Labor collects data concerning estimated employment and projected employment in the United States.<sup>6</sup> In addition to employment data, the BLS provides biannual reports about education or training requirements for hundreds of occupations, including radiologic technology.<sup>7</sup> Each occupation is assigned a 6-digit BLS Standard Occupational Classification code.

This study focuses on 4 specific BLS occupation categories:

- Radiologic technologists and technicians (29-2037).

- Diagnostic medical sonographers (29-2032).
- Nuclear medicine technologists (29-2033).
- Radiation therapists (29-1124).

The cardiovascular technologists and technicians (29-2031) occupation category is not included in the study because the BLS *Occupational Outlook Handbook* states that individuals who want to study echocardiography and vascular sonography may attend diagnostic medical sonography programs and because electrocardiograph technicians — a large number of the workers included in the category — are trained on the job and outside the radiologic science profession.

The BLS produces annual national employment estimates for each occupation for the month of May of the previous year.<sup>8</sup> Table 1 gives the employment estimates and the mean wages for 2006, 2007, 2008, 2009, and 2010. Although the radiologic science workforce has steadily increased, the percentages of workers in each category are constant over the 5-year period with:

- Radiologic technologists and technicians (29-2037) at 71%.
- Diagnostic medical sonographers (29-2032) at 17%.
- Nuclear medicine technologists (29-2033) at 7%.
- Radiation therapists (29-1124) at 5%.

To obtain these percentages from Table 1, simply choose an annual employment number for a particular occupational category and then divide by the total employment in the radiologic and imaging sciences profession for that chosen year.

Table 2 gives the BLS employment numbers and the projected employment numbers for the 4 radiologic science occupation categories for the decade 2008 to 2018.<sup>7</sup> Overall, the total projected employment numbers for radiologic science professionals for the year 2018 appear to be favorable, with the aggregate growth in employment during the 10-year projection being in the 14% to 19% range, which is considered growth faster than average by the BLS. Of course, population and demographics play a large role in this projected employment growth, as the relative aging of the U.S. population and the retirement of many baby boomer health care workers are among the most important factors considered in the BLS projection. In addition, some differences in employment growth exist between the 4 radiologic science categories discussed in this study.

For radiologic technologists and technicians (29-2037), which includes professionals working in radiography, computed tomography, MR imaging,

**Table 1**  
**Annual Employment and Wage Data for the Radiologic Sciences<sup>8</sup>**

BLS Standard Occupation Classification (No.)	May 2006 Employment (Mean Wages)	May 2007 Employment (Mean Wages)	May 2008 Employment (Mean Wages)	May 2009 Employment (Mean Wages)	May 2010 Employment (Mean Wages)
Radiologic Technologists and Technicians <sup>a</sup> (29-2037)	190 180 (\$49 320)	200 370 (\$51 150)	208 570 (\$53 230)	213 560 (\$54 180)	216 730 (\$55 730)
Diagnostic Medical Sonographers (29-2032)	44 340 (\$58 110)	46 770 (\$60 590)	48 920 (\$62 660)	51 630 (\$63 640)	53 010 (\$64 900)
Nuclear Medicine Technologists (29-2033)	19 270 (\$63 000)	20 410 (\$65 380)	21 200 (\$67 480)	21 670 (\$68 450)	21 600 (\$69 050)
Radiation Therapists (29-1124)	14 290 (\$67 580)	14 620 (\$71 990)	14 850 (\$75 450)	15 570 (\$77 340)	16 590 (\$78 290)
Overall Radiologic Science Profession	268 080 (\$52 731)	282 170 (\$54 824)	293 540 (\$56 955)	302 430 (\$58 010)	307 930 (\$59 458)

<sup>a</sup>Term used by the U.S. Department of Labor.  
BLS = Bureau of Labor Statistics

and mammography, employment is expected to grow faster than average (17%) between 2008 and 2018.<sup>9</sup> Technologists who acquire skills in more than 1 modality have the best employment opportunities. The BLS notes that formal education and training programs in radiography can lead to a certificate, an associate degree, or a bachelor's degree. However, beginning in 2015, a certificate will no longer be acceptable for certification eligibility.

For diagnostic medical sonographers (29-2032), future job opportunities should be favorable, according to the BLS.<sup>10</sup> The BLS indicates that employment will grow 18% during the decade 2008 to 2018, as ultrasonography becomes an attractive alternative to other diagnostic imaging modalities. According to the BLS, education and training programs in diagnostic medical sonography are offered in hospitals, vocational-technical institutions, colleges, universities, or the armed forces.

For nuclear medicine technologists (29-2033), the BLS suggests that despite employment growth of 16% from 2008 to 2018 in nuclear medicine, the number of job openings each year in this occupation category will be relatively low because the supply of nuclear medicine technologists will exceed the number of job openings.<sup>11</sup> Again, the BLS has apparently not taken into account the upcoming ARRT and NMTCB changes to education requirements, beginning in 2015

and 2016 respectively. The BLS states that nuclear medicine technology programs can range from 1 to 4 years and can lead to a certificate, an associate degree, or a bachelor's degree.

The BLS is projecting the strongest employment growth between 2008 and 2018 for radiation therapists (29-1124), with employment projected to grow by 27%.<sup>12</sup> The BLS indicates that a certificate, an associate degree, or a bachelor's degree in radiation therapy is required for employment in this occupation category. However, a certificate alone will not meet the requirement for ARRT radiation therapy examination eligibility beginning in 2015.

Although no single authoritative source exists for data concerning the award offerings of radiologic technology education programs, the JRCERT, JRCNMT, and the Joint Review Committee on Education in Diagnostic Medical Sonography (JRC-DMS) publish lists of programmatically accredited education programs that include the academic awards provided to students of those programs.<sup>13-15</sup> The Commission on Accreditation of Allied Health Education Programs (CAAHEP) maintains the list of programmatically accredited diagnostic medical sonography education programs for the JRC-DMS.<sup>16</sup>

In addition, the American Society of Radiologic Technologists (ASRT) conducts an annual survey to estimate the award offerings of certain professional

**Table 2**  
**Projected Employment Growth Projection for the Radiologic Sciences – 2008 to 2018<sup>7</sup>**

BLS Standard Occupation Classification (No.)	2008 BLS N	2018 BLS N	2008 to 2018 Employment Growth Projection N (%)
Radiologic Technologists and Technicians <sup>a</sup> (29-2037)	214 700	251 700	37 000 (17)
Diagnostic Medical Sonographers (29-2032)	50 300	59 500	9200 (18)
Nuclear Medicine Technologists (29-2033)	21 800	25 400	3600 (16)
Radiation Therapists (29-1124)	15 200	19 400	4100 (27)
Overall Radiologic Science Profession	302 000	356 000	54 000 (18)

<sup>a</sup>Term used by the U.S. Department of Labor.  
 BLS = Bureau of Labor Statistics

education programs recognized by the ARRT.<sup>17</sup> The *Enrollment Snapshot of Radiography, Radiation Therapy and Nuclear Medicine Technology Programs 2010* was e-mailed to 1009 radiography, radiation therapy, and nuclear medicine technology program directors. When the response period closed in December 2010, 629 responses had been received, for an overall response rate of 62%. According to respondents, graduates received certificates (25.3%), associate degrees (58.5%), bachelor's degrees (15.9%), or other academic awards (0.3%). The survey results were aggregated and the percentages are not given for each specific discipline or specialty. Of the program representatives responding to the ASRT survey, 99% were located in the United States.

**Methods**

The methods used in this study to identify radiologic science programs and to determine the academic awards they offer upon graduation are straightforward, but rather time consuming. First, an education program was considered for inclusion if it was located in the United States and the program covered 1 of the following disciplines or specialties:

- Diagnostic medical sonography.
- MR imaging.
- Medical dosimetry.
- Nuclear medicine technology.
- Radiation therapy.
- Radiography.

■ R.R.A.

Next, the education programs were identified by searching the Internet databases of the accrediting agencies and certifying bodies. Finally, the academic awards given to students graduating from the programs identified were determined by either using the accrediting agency databases or by searching academic institution websites for the academic award data, when the program was not programmatically accredited. The study data were obtained during May 2011.

If an academic institution indicated that it had closed the education program or that the program was inactive, it was excluded from consideration in the study.

Because some academic institutions offer more than 1 possible academic award for graduation from the program, the results for this study were tabulated in 2 different ways: the *highest* academic awards available and the *lowest* academic awards available from each education program. For example, if an academic institution offered the possibility of a certificate or an associate degree to a student upon graduation, then the award was tabulated for the education program as being an associate degree for the highest award scenario and was tabulated as being a certificate for the lowest award scenario.

The actual number of different academic awards being granted to radiologic science program graduates in the United States is clearly somewhere between these 2 limiting scenarios.

For diagnostic medical sonography programs, the accrediting agencies are the JRC-DMS and CAAHEP. On the CAAHEP website, 185 programmatically accredited programs were listed.<sup>16</sup> The 2 certifying body websites accessed for ultrasonography were those of the American Registry for Diagnostic Medical Sonography (ARDMS) and the ARRT. The ARDMS itself does not maintain a list of recognized programs, but rather refers to the CAAHEP list. On the ARRT website, 84 recognized sonography education programs were listed.<sup>18</sup> Sixty-six programs appeared on both the ARRT and CAAHEP lists.<sup>16,18</sup> In total, 203 separate diagnostic medical sonography programs were identified.

For MR, the accrediting agency is the JRCERT, which listed 3 programmatically accredited programs.<sup>14</sup> The 2 certifying body websites accessed for MR were the American Registry of Magnetic Resonance Imaging Technologists (ARMRIT) and the ARRT. The ARMRIT website included 20 recognized programs, and the ARRT website had 17.<sup>18,19</sup> None of the programs on the ARMRIT list were listed by either the JRCERT or the ARRT. Three MR programs on the ARRT list were also on the JRCERT list. In total, 37 separate MR education programs were identified.

For medical dosimetry education programs, the accrediting agency is the JRCERT. On the JRCERT website, 16 programmatically accredited medical dosimetry programs are named. MDCB was the certifying body website accessed for medical dosimetry. The MDCB does not maintain a list of recognized medical dosimetry education programs, but refers to the JRCERT list, so 16 separate medical dosimetry programs were identified.

For nuclear medicine technology education programs, the accrediting agency is the JRCNMT. The JRCNMT website listed 98 programmatically accredited programs.<sup>13</sup> The 2 certifying body websites accessed were those of the NMTCB and the ARRT. On the NMTCB and ARRT websites, 121 identical recognized nuclear medicine programs appeared.<sup>4,18</sup> All 98 of the nuclear medicine programs on the JRCNMT list are on the NMTCB and ARRT lists. In total, 121 separate programs were identified.

For radiation therapy education programs, the accrediting agency is the JRCERT. The JRCERT website listed 82 programmatically accredited radiation therapy programs. The certifying body website accessed for radiation therapy was that of the ARRT, where 98 recognized programs are named.<sup>18</sup> All 82 programs on the

JRCERT list are on the ARRT list. In total, 98 separate radiation therapy education programs were identified.

For radiography education programs, the accrediting agency is the JRCERT. On the JRCERT website, 639 programmatically accredited radiography programs appeared. The ARRT, the certifying body accessed, recognized 718 radiography education programs.<sup>18</sup> All 639 radiography programs on the JRCERT list are on the ARRT list. In total, 718 separate radiography education programs were identified.

No formal programmatic accrediting agency exists for registered radiologist assistant education programs. However, the ARRT website was accessed for RRA, which listed 12 programs.<sup>18</sup>

## Results

The total number of radiologic science programs identified for inclusion in the study was 1205. The total number of programs in the United States recognized by the ARRT for radiography, nuclear medicine, radiation therapy, MR, and ultrasonography primary pathway exam eligibility was 1038.<sup>18</sup> The 167 programs not recognized by the ARRT but included in the study are ultrasonography, MR, and medical dosimetry programs recognized by other certifying bodies, such as ARDMS, ARMRIT, and MDCB.

It is interesting to make the following 4 groupings of the 1205 radiologic science programs:

- Radiography, MR, and radiologist assistant had 767 separate education programs (63.7%).
- Diagnostic medical sonography had 203 separate education programs (16.8%).
- Nuclear medicine technology had 121 separate education programs (10.0%).
- Radiation therapy and medical dosimetry had 114 separate education programs (9.5%).

Although the average number of students graduating from a program grouping could vary, comparing these grouping percentages to the percentage of workers in each occupation category of Table 1 and Table 2 showed close alignment. For the long term, this suggests that labor market forces largely determine the number of radiologic science professional education programs.

However, the goal of this study is to estimate the short-term effect of increases in the minimum education requirements for entry into the radiologic science job market. The relative size of the likely short-term effect can be estimated by examining the highest and lowest award scenario numbers (see Table 3). Between



**Table 3  
Awards Offered to Graduates by Radiologic Science Education Programs in May 2011**

Professional Education Programs (N)	Certificate n (%)		Associate Degree n (%)		Bachelor's Degree n (%)		Master's Degree n (%)	
	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest
<b>Award Scenario</b>								
<b>Diagnostic Medical Sonography Total (203)</b>	<b>67 (33)</b>	<b>98 (48)</b>	<b>108 (53)</b>	<b>81 (40)</b>	<b>27 (13)</b>	<b>24 (12)</b>	<b>1 (1)</b>	<b>0 (0)</b>
ARRT Primary (84)	29 (34)	43 (51)	46 (55)	36 (43)	9 (11)	5 (6)	0 (0)	0 (0)
JRC-DMS/CAAHEP (185)	64 (35)	95 (51)	95 (51)	67 (36)	25 (13)	23 (13)	1 (1)	0 (0)
<b>Magnetic Resonance Total (37)</b>	<b>24 (65)</b>	<b>26 (70)</b>	<b>5 (13)</b>	<b>3 (8)</b>	<b>8 (22)</b>	<b>8 (22)</b>	<b>0 (0)</b>	<b>0 (0)</b>
ARRT Primary (17)	7 (41)	9 (53)	2 (12)	0 (0)	8 (47)	8 (47)	0 (0)	0 (0)
ARMRIT (20)	17 (85)	17 (85)	3 (15)	3 (15)	0 (0)	0 (0)	0 (0)	0 (0)
JRCERT (3)	2 (67)	2 (67)	0 (0)	0 (0)	1 (33)	1 (33)	0 (0)	0 (0)
<b>Medical Dosimetry Total (16)</b>	<b>8 (50)</b>	<b>10 (62)</b>	<b>0 (0)</b>	<b>0 (0)</b>	<b>4 (25)</b>	<b>3 (19)</b>	<b>4 (25)</b>	<b>3 (19)</b>
JRCERT (16)	8 (50)	10 (62)	0 (0)	0 (0)	4 (25)	3 (19)	4 (25)	3 (19)
<b>Nuclear Medicine Total (121)</b>	<b>40 (33)</b>	<b>65 (54)</b>	<b>41 (34)</b>	<b>31 (25)</b>	<b>40 (33)</b>	<b>25 (21)</b>	<b>0 (0)</b>	<b>0 (0)</b>
ARRT Primary (121)	40 (33)	65 (54)	41 (34)	31 (25)	40 (33)	25 (21)	0 (0)	0 (0)
NMTCB (121)	40 (33)	65 (54)	41 (34)	31 (25)	40 (33)	25 (21)	0 (0)	0 (0)
JRCNMT (98)	35 (36)	51 (52)	29 (29)	24 (25)	34 (35)	23 (23)	0 (0)	0 (0)
<b>Radiation Therapy Total (98)</b>	<b>35 (36)</b>	<b>48 (49)</b>	<b>28 (28)</b>	<b>20 (20)</b>	<b>35 (36)</b>	<b>30 (31)</b>	<b>0 (0)</b>	<b>0 (0)</b>
ARRT Primary (98)	35 (36)	48 (49)	28 (28)	20 (20)	35 (36)	30 (31)	0 (0)	0 (0)
JRCERT (82)	31 (38)	42 (51)	20 (24)	14 (17)	31 (38)	26 (32)	0 (0)	0 (0)
<b>Radiography Total (718)</b>	<b>192 (27)</b>	<b>207 (29)</b>	<b>484 (67)</b>	<b>477 (66)</b>	<b>42 (6)</b>	<b>34 (5)</b>	<b>0 (0)</b>	<b>0 (0)</b>
ARRT Primary (718)	192 (27)	207 (29)	484 (67)	477 (66)	42 (6)	34 (5)	0 (0)	0 (0)
JRCERT (639)	190 (30)	198 (31)	415 (65)	414 (65)	34 (5)	27 (4)	0 (0)	0 (0)
<b>Radiologist Assistant Total (12)</b>	<b>0 (0)</b>	<b>0 (0)</b>	<b>0 (0)</b>	<b>0 (0)</b>	<b>3 (25)</b>	<b>3 (25)</b>	<b>9 (75)</b>	<b>9 (75)</b>
ARRT (12)	0 (0)	0 (0)	0 (0)	0 (0)	3 (25)	3 (25)	9 (75)	9 (75)
<b>Professional Education Programs Total (1205)</b>	<b>366 (31)</b>	<b>454 (38)</b>	<b>666 (55)</b>	<b>612 (51)</b>	<b>159 (13)</b>	<b>127 (10)</b>	<b>14 (1)</b>	<b>12 (1)</b>
<b>ARRT Primary Education Programs Total (1038)</b>	<b>303 (29)</b>	<b>372 (36)</b>	<b>601 (58)</b>	<b>564 (54)</b>	<b>134 (13)</b>	<b>102 (10)</b>	<b>0 (0)</b>	<b>0 (0)</b>

ARRT = American Registry of Radiologic Technologists  
 JRC-DMS = Joint Review Committee on Education in Diagnostic Medical Sonography  
 CAAHEP = Commission on Accreditation of Allied Health Education Programs  
 ARMRIT = American Registry of Magnetic Resonance Imaging Technologists  
 JRCERT = Joint Review Committee on Education in Radiologic Technology  
 NMTCB = Nuclear Medicine Technology Certification Board  
 JRCNMT = Joint Review Committee on Educational Programs in Nuclear Medicine Technology

31% and 38% of programs awarded certificates to graduating students in May 2011, whereas 29% to 36% of ARRT-recognized programs during the same period awarded graduating students certificates. Thus, the relative size of the short-term effect of increasing the education requirement from a certificate to an associate degree on projected employment opportunities appears to be large and non-negligible, because approximately one-third of professional education programs currently award certificates to their graduates.

### Discussion

The current situation with regard to the degree granting status of professional education programs could be better understood with an example. According to JRCERT Chief Executive Officer Leslie Winter, MS, R.T.(R), of the 160 hospital-based programmatically accredited radiography programs that currently grant certificates, 119 (74%) have an articulation agreement in place (personal communication, September 7, 2011). An articulation agreement creates a partnership through which students in a hospital-based program earn credits toward a degree from a community college or university. However, 41 (26%) of these radiography programs do not have a transition plan in place. Further, according to the JRCERT, only 6 formerly hospital-based programmatically accredited certificate radiography programs transferred the sponsorship of their program from a hospital to a community college during the past year. Because the degree requirement presents the profession with an entirely new situation, we do not know if articulation agreements with community colleges and universities will suffice to maintain the viability of hospital-based certificate programs.

In addition, the website searches conducted for this study suggested that some programs have closed in recent years, most notably in nuclear medicine technology and radiography, indicating cutbacks — not growth — in professional education programs.

The cutbacks, as well as the small number of certificate programs transitioning to degree programs or partnering with community colleges and universities, may well be due to the severe global recession that began in December 2007 and took a particularly sharp downward turn in September 2008. Perhaps unfortunately, this “Great Recession” has coincided with the period in which many education programs have been transitioning to offer students an associate degree upon program completion.

In any case, the aging baby boomers will require more services provided by radiologic science professionals, as indicated by the BLS projection numbers.

### Conclusion

Projected employment opportunities in the United States for radiologic science professionals could grow even faster than the BLS has expected, because the supply of graduates from professional education programs who meet the increased minimum education requirement could become limited in the short term. The short-term situation could become particularly acute because associate degree education programs are 2 years long. If students must have an associate degree in 2015 to be eligible for an ARRT primary examination, then many of those students must matriculate into an associate degree education program by 2013, if they do not already have a degree when they enter the program.

Although approximately one-third of professional education programs currently award students with certificates, this situation can and will change in the long term, as labor market forces will certainly react back on professional education in radiologic sciences to correct any short-term work force dislocations. The timing of those labor market reaction forces, however, appears to be in question. At present, it does not appear from the data obtained for this study that certificate-based professional education programs have fully reacted to the changes coming in 2015 by making the transitions necessary to offer an associate degree.

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*Richard H Weening, PhD, MIPP, R.T.(R)(CT)(MR), FAEIRS, is an associate professor of radiologic sciences and director of the computed tomography and magnetic resonance imaging programs at Thomas Jefferson University in Philadelphia, Pennsylvania, as well as a visiting scientist at the Princeton Plasma Physics Laboratory in Princeton, New Jersey. He can be reached at [richard.weening@jefferson.edu](mailto:richard.weening@jefferson.edu).*

*Reprint requests may be sent to the American Society of Radiologic Technologists, Communications Department, 15000 Central Ave SE, Albuquerque, NM 87123-3909, or e-mail [communications@asrt.org](mailto:communications@asrt.org).*

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**Monthly Statistics**  
July 2013

<u>Institution Type</u>	<u>Award</u>	<u>Radiography</u>	<u>Radiation Therapy</u>	<u>Medical Dosimetry</u>	<u>Magnetic Resonance</u>
4 Year College/University	Certificate	5	1	6	0
	Associate Degree	75	0	0	0
	Baccalaureate Degree	35	31	2	4
	Master Degree	0	0	3	0
Community College	Certificate	1	6	1	0
	Associate Degree	256	14	0	0
	Baccalaureate Degree	0	0	0	0
Technical College/Institute	Certificate	16	1	0	0
	Associate Degree	51	3	0	0
	Baccalaureate Degree	0	0	0	0
Hospital	Certificate	143	19	4	2
	Associate Degree	7	0	0	0
	Baccalaureate Degree	1	0	1	0
Military/Government	Certificate	1	0	0	0
	Associate Degree	0	0	0	0
	Baccalaureate Degree	0	0	0	0
Proprietary	Certificate	4	2	0	0
	Associate Degree	36	2	0	0
	Baccalaureate Degree	1	0	0	0
Consortium	Certificate	0	0	0	0
	Associate Degree	1	0	0	0
	Baccalaureate Degree	0	0	0	0
		<b>633</b>	<b>79</b>	<b>17</b>	<b>6</b>
Intent to discontinue 7/2/13 thru 12/31/13		6	1	0	0
Inactive		1	2	0	0

**Interest in BSMI Degree at IPFW  
Survey Response Summary**

	<b>Current IPFW Students – Initial Survey</b>	<b>Current IPFW Students – Follow-up Question</b>	<b>Technologists</b>
<b>No. of Respondents</b>	<b>55/154</b>	<b>36/154</b>	<b>44/152</b>
<b>Response Rate</b>	<b>36%</b>	<b>23%</b>	<b>29%</b>
What is the Highest level of education you have completed?	N/A	N/A	AS Degree = <b>38 (86%)</b> BS Degree = <b>6 (14%)</b>
If you had the option to earn a Bachelor Degree in Medical Imaging at IPFW, would you?	Yes, Full Time = <b>28 (51%)</b> Yes, Part Time = <b>26 (47%)</b> Maybe = <b>0 (0%)</b> No = <b>1 (2%)</b>	N/A	Yes, Full Time = <b>1 (2%)</b> Yes, Part Time = <b>16 (36%)</b> Maybe = <b>16 (36%)</b> No = <b>11 (25%)</b>
What area/concentration would you choose for your Bachelor Degree? (Choose all that apply)	Gen Rad = <b>9 (16%)</b> Leadership/ Management = <b>2 (4%)</b> Ultrasound = <b>14 (25%)</b> CT = <b>8 (15%)</b> MRI = <b>5 (9%)</b> Interventional = <b>2 (4%)</b> Nuc Med = <b>0 (0%)</b> Rad Therapy = <b>8 (15%)</b> Other = <b>5 (9%)</b> N/A = <b>2 (4%)</b>	N/A	Gen Rad = <b>11 (26%)</b> Leadership/ Management = <b>11 (26%)</b> Ultrasound = <b>3 (7%)</b> CT = <b>12 (28%)</b> MRI = <b>9 (21%)</b> Interventional = <b>2 (5%)</b> Nuc Med = <b>2 (5%)</b> Rad Therapy = <b>4 (9%)</b> Other = <b>3 (7%)</b> N/A = <b>7 (16%)</b>
Please select your primary motivation for pursuing a Bachelor degree.	Marketable Skills = <b>21 (38%)</b> Improve Performance or Pay = <b>22 (40%)</b> Complete BS previously started = <b>1 (2%)</b> Enrichment = <b>4 (7%)</b> Prep for 1 <sup>st</sup> Real Job = <b>2 (4%)</b> Tuition Asst = <b>1 (2%)</b> Other = <b>2 (4%)</b> N/A = <b>2 (4%)</b>	N/A	Marketable Skills = <b>14 (33%)</b> Improve Performance or Pay = <b>10 (24%)</b> Complete BS previously started = <b>2 (5%)</b> Enrichment = <b>3 (7%)</b> Prep for 1 <sup>st</sup> Real Job = <b>0 (0%)</b> Tuition Asst = <b>3 (7%)</b> Other = <b>2 (5%)</b> N/A = <b>8 (19%)</b>
If you were to take classes toward a Bachelor Degree in Medical Imaging at IPFW, would you take (choose all that apply)	N/A	Online = <b>19 (53%)</b> Face to Face = <b>32 (89%)</b> Hybrid = <b>17 (47%)</b>	Online = <b>27 (64%)</b> Face to Face = <b>10 (24%)</b> Hybrid = <b>21 (50%)</b>
If you had the option at the beginning of the Radiography Program, which of the following would you have pursued?	N/A	BS at IPFW = <b>34 (94%)</b> AS elsewhere = <b>2 (6%)</b>	BS at IPFW = <b>25 (93%)</b> AS elsewhere = <b>2 (7%)</b> (only 27 responses received for this question)

#### **4.13 – Employment Opportunities - Radiography**

- ASRT Job Bank - <http://www.asrt.org/main/careers>
- iHire Radiology - [www.ihireradiology.com/](http://www.ihireradiology.com/)
- Indeed Job Search – [www.indeed.com/](http://www.indeed.com/)

Dr. Jeffery R. Anderson  
Vice Chancellor of Academic Affairs  
Indiana University-Purdue University Fort Wayne  
2101 E. Coliseum Blvd  
Fort Wayne, IN 46835

Dear Dr. Anderson

It has come to my attention that IPFW Department of Radiography is considering a Bachelor of Science in Medical Imaging degree. I believe this type of degree would be very beneficial to our professional field and health care facilities. Students would have more opportunities for employment with this type of degree.

Currently, as a manager of the radiology department of St. Joseph Hospital, I am always looking to hire radiographers who have been educated in more than one modality, especially radiography and computerized tomography. These individuals are more versatile employees than single modality technologists. During these economic times, it is advantageous to hire employees that have the ability to cover more areas in your department. If all radiographers are educated in an additional modality leading to advanced credentials, there will be less cross-training and orientation time for the hospital.

By utilizing the fourth year to offer education and experience in an additional modality, it will provide the need that many radiographers have in obtaining advanced credentials. Many employers are beginning to require advanced credentials for technologists in order to earn ACR (American College of Radiology) accreditation for different modalities in their hospital. An additional year of honing their knowledge and skills in radiography and an advanced modality helps promote excellent care to their patients and is beneficial to any hospital.

I fully support a Bachelor of Science in Medical Imaging Degree and hope you consider this proposal without any reservations.

Sincerely,



Karen Brehm  
Operations Manager  
St. Joseph Hospital  
Fort Wayne, IN



February 21, 2013

Dr. Jeffrey R. Anderson, Vice Chancellor of Academic Affairs  
Indiana University-Purdue University Fort Wayne  
2101 E. Coliseum Blvd.  
Fort Wayne, IN 46805

Dear Dr. Anderson,

I would like to support the Radiography Program's proposal to revise their current program degree offering from an Associate to a Baccalaureate. I begin my support with evidence of this statement from radiology's national professional society and author of radiology curricula and national practice standards: "The American Society of Radiologic Technologists (ASRT) recognizes the baccalaureate degree as the professional level of radiologic science education (2007)." In addition, the national accrediting agency for radiology programs, The Joint Review Committee on Education in Radiologic Technology (JRCERT), also recognizes several Baccalaureate degree programs in radiology. I am a clinical assistant professor at the University of Southern Indiana (USI), which currently is the only Baccalaureate program in radiologic technology in the State of Indiana. While USI offered a Bachelors of Science degree in Radiology beginning in 2005, the program's bachelor's degree became accredited with the JRCERT in 2009. At the time USI's program was the 32<sup>nd</sup> JRCERT accredited bachelors program in the United States. In addition to my position within a BS program at USI, I also serve on a practice standards committee for the radiology profession at a national level.

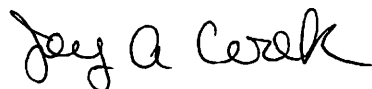
Having been in the field of radiology for eighteen years and formally teaching eight of those years, I have witnessed the change in curriculum for entry level technologists. The Associate degree curriculum covers common knowledge items needed for entry level professionals in the field of radiology. The Bachelor's degree curriculum established in 2007, combines the entry level skills and knowledge needed by the entry-level radiographer, but adds curricula supportive of advanced clinical practice in advanced specialty imaging as well as transitions into leadership roles and positions. As an educator in a Baccalaureate program, I have witnessed the benefits my students have received from their advanced degree. Students graduating with a Bachelor's of Science (BS) in Radiologic and Imaging Science have been immediately eligible for advanced practice in cross sectional

imaging modalities as well as advanced imaging roles. Numerous employers of our students have commented that they have chosen our BS student's over other AS degree or certificate students because of their advanced education in imaging. In addition, feedback has been extremely positive in areas that include "shorter employee training time". A bachelor's degree places students in a good position for the management and upward mobility potential that will limit the professional with an associate degree. With the increasing complexity and technical advancement of the radiology profession, little room is left for those without the bachelor's degree.

Another consideration in my support for the degree change comes from new state requirements. State of Indiana mandate on program curricular hours leaves minimal accommodation for an associate degree program and the entire required radiology curriculum within the prescribed sixty hours. Even with potential exceptions at the state level, associate degree curriculum is considerably sizeable and at a minimum will well exceed the sixty hours by 20 credit hours or more. Bachelor's degree curriculum, while still emphasizing the entry level knowledge and skills, can be accomplished within the 120 state prescribed hours.

Thank you for the opportunity to discuss my support in this requested change. I welcome the opportunity to discuss any aspect of this letter with you. Please feel free to contact me at (812) 465-1183.

Sincerely,



Joy A. Cook, MEd., RT (R)(CT)(MR)(ARRT)  
Clinical Assistant Professor and Clinical Coordinator  
University of Southern Indiana  
Radiologic & Imaging Sciences Program





August 28, 2013

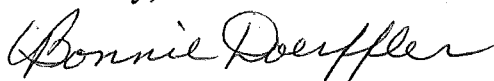
Dr. Jeffrey R. Anderson  
Vice Chancellor of Academic Affairs  
Indiana University-Purdue University  
Fort Wayne

I am writing this letter in support of a Bachelor of Science in Medical Imaging program at the Indiana University-Purdue University Fort Wayne campus. Due to the changes in technology in the Imaging field and the amount of information our students need to be prepared to work in this field, I believe they need more time than an Associate's degree can offer. I know their curriculum is over-crowded and already takes three years to complete. There are so many students who would prefer a Bachelor's degree, and with the amount of credits they already take it would be beneficial for them to graduate with a bachelor of science.

It is important to have more students trained in the specialty fields, such as CT or MRI, when they graduate so they will be more prepared as a cross-trained radiographer. We no longer have the resources to train "on the job" in specialty areas of Imaging like we used to. PACS, digital imaging, and electronic medical records are so important to have a good understanding upon graduation. I would also like to see more courses in quality management, with the ever-changing regulations and quality indicators that we must audit it would be beneficial for them and to me as the hiring manager.

I look for radiographer's that can offer specialty skills when I hire and a Bachelor of Science in Medical Imaging will offer that. The changing future in all imaging modalities depends on this expanded education for our students.

Sincerely,



Bonnie Doerffler, BS, RT(R)(M)  
Imaging Manager  
Parkview Hospital

Dear Dr. Jeffrey R. Anderson, Vice Chancellor of Academic Affairs for IPFW:

I am writing this letter in support for the initiation of a Bachelor of Science in Medical Imaging (BSMI) degree at Indiana University - Purdue University Fort Wayne. I am a radiology physician in practice with Fort Wayne Radiology since 1989 with a specialty interest in nuclear medicine and have been actively involved with the school of radiography since the early 1990s as a clinical advisor. The field of radiology is one of the most exciting and rapidly changing specialties in medicine requiring highly trained radiologic technologists. The complexity of imaging techniques continues to grow with exciting technologies looming on the horizon, i.e. biomolecular imaging.

The BSMI degree would keep IPFW at the forefront in training skilled radiographers and provide much needed skilled labor to this area and the surrounding communities. Therefore, I most highly recommend the Bachelor of Science in Medical Imaging degree to you for institution at Indiana University- Purdue University Fort Wayne.

Sincerely:

Michael A. Kinzer, MD, FACR

September 10, 2013

Dr. Jeff Anderson  
Vice Chancellor for Academic Affairs  
Indiana University Purdue University Fort Wayne  
2101 East Coliseum Boulevard  
Kettler Hall 169  
Fort Wayne, IN 46805

Dear Dr. Anderson:

I am writing to express my support for the development of a Bachelor of Science in Medical Imaging Program at your University. Medical Imaging is a rapidly changing profession with consistent technological advancements that are necessitating the need for additional education in order for technologists to remain current in their practice and marketable with their skills. These advancements have also created the need for technologists with a higher level of critical thinking and decision-making skills than the traditional medical imaging professional practice of the past. The advent of new specialties and modalities like CT and MR are also creating the need for a more comprehensive baccalaureate model in medical imaging. There is much discussion nationally among medical imaging educators about the inability to teach what is necessary for today's practice environment in a 2-year associate degree program and the need to expand the programs to include more subspecialties. From this perspective the proposed baccalaureate program will be at the forefront of a national movement toward baccalaureate education in medical imaging.

I understand that the program will also provide advanced placement for registered technologists, which is the model that most educators are advocating and that ASRT endorses. This will allow many practicing technologists to return to school to enhance their skills and also provide career mobility and advancement.

As the CEO of The American Society of Radiologic Technologists, I am very pleased to provide this letter of support for the development of a baccalaureate program in Medical Imaging at Indiana University Purdue University Fort Wayne.

September 10, 2013  
Dr. Jeff Anderson  
Page two

ASRT endorses this movement toward baccalaureate education and is willing to assist your faculty in this transition. Please feel free to contact me if you have any additional questions.

Sincerely,

A handwritten signature in black ink that reads "S. Martino". The signature is written in a cursive style with a large, stylized initial "S".

Sal Martino, Ed.D., R.T.(R), CAE  
Chief Executive Officer  
American Society of Radiologic Technologists  
15000 Central Ave, SE  
Albuquerque, NM 87123-3909  
Phone: 800-444-2778, Ext. 1259 or 505-298-4500, Ext. 1259  
[smartino@asrt.org](mailto:smartino@asrt.org)

# David Powell MD

3707 New Vision Drive • Fort Wayne, [State] 46835 • Phone: 260-471-9466 • Fax: 260-484-4919  
E-Mail: Davep@fwradiology. Web: fwradiology.com



5.14  
(6 of 6)

Date: July 22, 2013

Dr. Jeffrey R. Anderson,  
Vice Chancellor of Academic Affairs  
Indiana University-Purdue University Fort Wayne, IN

Dear Dr. Anderson:

I would like introduce myself. I am David K. Powell MD, a radiologist in Fort Wayne, a native of Fort Wayne, and graduate of IPFW BA(Chem major)1979. I am a graduate of Hahnemann University College of Medicine(now Drexel Med). I did a residency in Diagnostic Radiology at the University of Illinois. I have practiced Diagnostic Radiology with FW Radiology LLC since 1989. We provide professional services in all of the Parkview Health System Hospitals and Clinics and also provide services at multiple other independent hospitals and clinics in our area. I have taught classes to Radiology Technology students and supervised Radiology Technology students in clinic for most of the years I have been in practice.

During my career with FW Radiology, I have learned to appreciate and benefit from the high quality work of many radiologic technology graduates from the IPFW. The high academic standards required for entrance into the program, the near perfect record of accomplishment on the required American Registry of Radiologic Technologist by graduates, and the high quality work performed by its graduates in the clinic are well known to potential employers in our area.

While the current program is an Associate degree program, current prerequisite courses have essentially added a year of study to the program. Additionally, the practice of radiology has changed significantly over the last 10 years or so. A transition from using film to acquire medical images to a digital format has increased the complexity of image acquisition. New medical image archive systems used in medical facilities require additional instruction in computer systems. There has also been rapid expansion of the use of cross sectional imaging (computed tomography, magnetic resonance) in routine medical practice, which requires additional instruction in the theory and operation of these sophisticated technologies.

With these facts in mind, I believe there is a need to expand the course offerings to include courses of instruction in these vital areas. Cheri Duncan, department of radiography chair, informs me that to include these areas of instruction would require the institution of a four year program of instruction, the BSMI(Bachelor of Science in Medical Imaging).

The degree, the BSMI, would go a long ways towards better meeting the needs of our regional employers, the hospitals and clinics providing these increasingly complex medical imaging services. The degree would also conceivably offer a pathway for those currently in the field in our area to broaden their education and advance their careers.

Thus, I would like to endorse the concept and encourage the institution of this important new degree program offering from the IPFW School of Radiography.

Sincerely,

David K. Powell MD  
FW Radiology LLC  
3707 New Vision Drive  
Fort Wayne, Indiana 46835

Ann,

As you are aware, the renovation last year totaled approximately \$56,000.

If we delete the shielding in the room and the heavy electrical for the x-ray apparatus, I would estimate the project will cost approx. \$35K - \$40K. This is highly dependant on the location as well.

I am assuming you will still need the structure above to hold the x-ray arm and the Philips cost to set the unit up.

Please let me know if you have any questions.

Thanks,  
GregJ



## Gregory Justice, RLA

**Project Manager**  
**Sustainability Coordinator**

[justiceg@ipfw.edu](mailto:justiceg@ipfw.edu)  
[www.ipfw.edu/physical-plant/](http://www.ipfw.edu/physical-plant/)

o: 260.481.6787

f: 260.481.4165

IPFW Project Management  
Ginsberg Hall, Room 104  
2101 E. Coliseum Blvd  
Fort Wayne, IN 46805

>>> Ann Oberfell 8/27/2013 5:33 PM >>>

We are in the process of putting together a proposal for a Bachelor of Science in Medical Imaging in CHHS. One of the associated costs is installing a second piece of x-ray equipment on campus. The equipment is in storage and it would not require everything that the other room had because it would not be energized to produce x-rays. So it would not require lead walls and extra power source - ceiling mounts, centering field light and locks.

I was hoping you could extrapolate from the cost of last summers installation and come up with a rough estimate for installation so we can include it in the proposal.

Any help would be greatly appreciated.

Ann

Ann M. Oberfell  
Dean and Professor  
College of Health and Human Services  
Indiana U.-Purdue U. Fort Wayne  
Neff Hall 142



1815 Washington St.  
Michigan City, IN 46360  
Ph: 800-710-4200  
Fax: (219) 874-8430

**QUOTE:** Q14362

**Quote Date:** October 9, 2013

**Quoted By:** CLM

*For questions regarding this quote, please contact:* Leslie Guzowski  
219-851-0650

#### Prepared For:

Indiana University/Purdue University – Fort Wayne  
2101 E Coliseum Blvd  
Fort Wayne, IN 46835

#### Quote Summary

Used Konica Regius 190 CR

**Customer Net Price: \$29,900.00**

*Price includes standard installation*

#### Quote Details:

### Used Konica Regius 190 Dual Bay CR System

- **Dual-Bay Computed Radiography Reader**
- 81 Plates per hour (14x17")
- 44 Seconds Cycle Time
- 12 bit grayscale output
- Auto sensing 100/1000 mbps Network Interface
- Power Conditioner
- **Includes CS-3 Control Station and Monitor**
- **Functionality:**
  - Reject Reason Tracking
  - Automatic Masking
  - Study List Filter
  - Hybrid Processing to further enhance visualization of detail and improve image latitude
  - Equalization, Frequency & Gradation Processing
  - HIPAA compliance enabling features (Audit trail, Auto log-out)
  - DICOM Store
  - DICOM Print
  - DICOM Modality Worklist
- *60 Day Warranty (30 days on cassettes)*
- **Cassettes**
  - Two (2) used 14x17" with imaging plates
  - Two (2) used 10x12" with imaging plates

**Terms and Conditions:**

**Quote valid for 30 days from quote date on page 1.  
Any applicable tax will be charged in addition to quoted price.**

Quoted prices will remain firm, with the exception of an industry-wide increase. Price includes standard system manuals. If System specifications are changed or modified at the request of Customer, RPS Imaging may, at its sole discretion, change System pricing.

RPS Imaging may refuse, consent, or impose additional charges and its own scheduling requirements as a condition of accepting rescheduling of an order beyond 30 days of original delivery or cancellation in full. Site preparation shall remain the responsibility of Customer.

**EXCEPT FOR ANY EXPRESS WARRANTIES STATED HEREIN, THE GOODS SOLD TO BUYER ARE PROVIDED ON AN "AS IS" BASIS, AND SELLER DISCLAIMS ANY AND ALL OTHER WARRANTIES, CONDITIONS, OR REPRESENTATIONS (EXPRESS, IMPLIED, ORAL OR WRITTEN), RELATING TO THE GOODS OR ANY PART THEREOF, INCLUDING, WITHOUT LIMITATION, ANY AND ALL IMPLIED WARRANTIES OR QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. NEITHER PARTY SHALL BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO, LOSS OF PROFITS, ARISING OUT OF THE USE OF OR THE INABILITY TO USE THE GOODS.**

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**Payment:**

- Lease/Finance                      Estimated Monthly Payment:  
60 Months - \*\$601.29  
\*Subject to completion of 3<sup>rd</sup> party leasing application and credit approval  
Leasing Company must comply with standard terms: 30 / 60 / 10
  
- Standard payment terms: 30% on Order / 60% on Shipment / 10% on Completion

***Note: Any payments made via credit card will be assessed a 3% surcharge***



Customer Acceptance:

Accepted By:

\_\_\_\_\_  
Authorized Signature

\_\_\_\_\_  
Printed Name

\_\_\_\_\_  
Date

\_\_\_\_\_  
PO Number (If Applicable)



**PB 123**  
**Proposal for**

# IUPU

# Fort Wayne

2101 East Coliseum Blvd  
Fort Wayne, IN

Customer Initials: \_\_\_\_\_ RPS Initials: \_\_\_\_\_  
Phone: (800) 710-4200 Fax: (219) 874-8430 Email: [rpsinfo@rpsimaging.com](mailto:rpsinfo@rpsimaging.com)  
Confidential Page 1 of 7 9/23/2013

Sales Contact:

For questions regarding this quote, please contact:

Leslie Guzowski

219-851-0650

PACS Proposal		
ID	QTY	Description Quote Number: 9182013/PM
<b>SOFTWARE</b>		
PB02	1	<p>Practice Builder 1-2-3® licensed for 2,500 study-per-year eRAD PACS application software for a single Server/Archive with Red Hat Linux O/S for customer sites performing up to 2,500 studies per year (feature set as described below). First year support and service included.</p> <p>eRAD® CORE SOFTWARE FOR PACS, DIAGNOSTIC VIEWING &amp; WORKFLOW MANAGEMENT</p> <ul style="list-style-type: none"> <li>- Unlimited concurrent-users and / or workstations;</li> <li>- Unlimited DICOM modality connections</li> <li>- Native web-based, single point of access for all users.</li> <li>- Integrated, downloadable, self-installing diagnostic viewer;</li> <li>- PACS-driven workflow;</li> <li>- Customizable worklist and workflow management;</li> <li>- User role-based security;</li> <li>- HIPAA compliant with audit trails;</li> <li>- Data coercion/manipulation engine;</li> <li>- User-defined hanging protocols;</li> <li>- Document Scanning or Upload/Attachment from Twain or WIA Compatible Scanner</li> <li>- DICOM Print</li> <li>- CD/DVD Burning</li> <li>- DICOM Forwarding</li> <li>- Multiplanar Reconstruction (MPR)</li> <li>- Worklist export to CSV file format for management reporting and data export (i.e. billing, practice mgmt systems)</li> </ul>
SW17	1	<p>DICOM MODALITY WORKLIST INTERFACE, ENTERPRISE LICENSE FOR INSTITUTIONAL/EDUCATION USE ONLY</p> <p>This license is not to be used for the Scheduling of real/live patients but only as a learning tool for students. Provides data exchange for devices capable of and licensed by the modality vendor to receive DICOM Modality Worklist data. DICOM MODALITY WORKLIST functionality is recommended when orders are received by or generated by eRAD.</p>
HW50	1	LINUX REDHAT OPERATING SYSTEM (OS) FOR eRAD
<b>HARDWARE</b>		
HW40	1	<p>2TB PB123 MAIN PACS SERVER</p> <p>Dell T110 mini-tower server with Intel® Core® I3 Dual Core processor; 2x 2TB SATA Hard drives w/ RAID 1; DVD Drive; Dual GB Network adaptor; 4 GB RAM; Keyboard; Mouse; 3-yr NBD warranty.</p>

Customer Initials: \_\_\_\_\_

RPS Initials: \_\_\_\_\_

Phone: (800) 710-4200 Fax: (219) 874-8430 Email: [rpsinfo@rpsimaging.com](mailto:rpsinfo@rpsimaging.com)

Confidential Page 2 of 7 9/23/2013

UPS	1	900W TOWER UNINTERRUPTABLE POWER SUPPLY (UPS)UPS protects against downtime, data loss and process interruption by providing continuous, clean power. Enables prolonged runtime of essential equipment during power outages by allowing for orderly, remote shutdown of non-critical systems or processes. 900w, 1500VA, 8 output receptacles, and 3 year manufacturer warranty. Battery runtimes varies on load.
<b>APPLICATIONS TRAINING &amp; SERVICES</b>		
TS508	2	PACS APPLICATIONS, ADMINISTRATOR TRAINING and INSTALLATION by RPS Imaging. RPS Imaging provides on-site, contiguous, eight (8)-hour days dedicated to training of customer personnel on use of eRAD PACS Viewer and Workflow applications.

<b>Your Price:</b>	<b>\$9,180.00</b>
<b>Payment Terms: 50% due upon order and 50% on delivery.</b>	
<b>Service Agreements Payment Terms: 100% before Starting Date of the Agreement.</b>	
<b>Installation within 60 days of acceptance of Down Payment</b>	
<b>Installation schedule will tentatively be set within 21 days of acceptance of order</b>	
<i>Typical installation begins with scheduling of delivery, installation engineers, and applications specialists. As delivery approaches, confirmation of network preparedness occurs. At least one week before installation engineer(s) arrive, scheduling of modality Field Service Engineer's for integration is required. On arrival of installation engineer, scope of delivery is confirmed and staging takes place. After staging equipment, installation commences. As system is brought on-line, any adjustments appropriate for software configurations are performed. After all modalities are proofed, installation is finished. Application training begins either later in the week or the following week and proceeds for the duration of the allocated application time.</i>	
<i>Price quoted includes normal installation, but does not include materials, services of plumbers, electricians, mechanics, helpers or for building changes. Preparation of the area is the responsibility of the purchaser. The above pricing does not reflect any applicable sales tax or freight.</i>	
<p><b>EXCEPT FOR ANY EXPRESS WARRANTIES STATED HEREIN, THE GOODS SOLD TO BUYER ARE PROVIDED ON AN "AS IS" BASIS, AND SELLER DISCLAIMS ANY AND ALL OTHER WARRANTIES, CONDITIONS, OR REPRESENTATIONS (EXPRESS, IMPLIED, ORAL OR WRITTEN), RELATING TO THE GOODS OR ANY PART THEREOF, INCLUDING, WITHOUT LIMITATION, ANY AND ALL IMPLIED WARRANTIES OR QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. NEITHER PARTY SHALL BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO, LOSS OF PROFITS, ARISING OUT OF THE USE OF OR THE INABILITY TO USE THE GOODS.</b></p> <p><b>IN THE EVENT RPS IMAGING IS THE PREVAILING PARTY IN ANY LITIGATION IN CONNECTION WITH THE ENFORCEMENT OF RPS'S RIGHTS IN CONNECTION WITH THIS PURCHASE AGREEMENT, OR TO DEFEND RPS AGAINST ANY CLAIMS MADE AGAINST RPS RELATING TO THE PURCHASE AGREEMENT, IN ADDITION TO ALL OTHER REMEDIES, RPS SHALL BE ENTITLED TO RECOVER ITS REASONABLE ATTORNEY FEES AND COSTS INCURRED IN CONNECTION WITH SAID LITIGATION.</b></p>	
<b>Customer Signature as Quoted:</b>	
<b>Customer Approval Date:</b>	
<b>RPS Confirmation of Order:</b>	
<b>Confirmation of Order Date:</b>	

**Customer Initials: \_\_\_\_\_ RPS Initials: \_\_\_\_\_**  
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**Confidential Page 3 of 7 9/23/2013**

<b>Time and Material:</b>		
<b>ID</b>	<b>QTY</b>	<b>Description</b>
NWT	1	• Travel billed at \$300.00 per hour.
NWS	1	• Labor billed at \$300.00 per hour.
TPS	1	• Third party software support (Charged at the Manufacturers rate).
HDW	1	• Third party hardware support (Charged at the Manufacturers rate).
PRS	1	• Remote Service (1/2 Hour Increments) billed at \$300.00 per hour.
<b>Pacs Block</b>	<b>1</b>	• 10 Hour Block Time Available at a discounted rate of \$2,700.00.

<b>Extended Service Contract Options:</b>	
<b>ONE YEAR EXTENDED SERVICE CONTRACT</b>	
Extended Service Contract may be purchased at current list rate, or the rate can be locked in at the discounted price noted below for software listed on this quotation.	
<b>Current list price:</b>	<b>\$2,341.00</b>
<b>1 year extended discounted Price:</b>	<b>\$1,756.00</b>
<b>Customer Signature as Quoted:</b>	

**eRAD PACS Terms & Conditions of Sale**

**BUYERS OBLIGATIONS**

**Site Preparation** All including the wiring of the LAN or WAN, is the responsibility of the Buyer. The Buyer is responsible for providing the appropriate LAN or WAN (including leased or dedicated inter-location data lines). All the equipment related to the network deployment, including, but not limited to: routers, switches, hubs, and firewalls, is the responsibility of the Buyer, unless otherwise specified. A broadband internet connection must be installed and operational for eRAD PACS. eRAD PACS must retain access rights as and administration rights to all servers and other hardware included in the system. Should any monitor shielding be required due to the MRI magnetic fringe fields, the cost of such shielding shall be the responsibility of the Buyer. eRAD PACS systems require use of recommended hardware or equivalents. ERAD PACS shall determine equivalencies. A Secure cage or room and Uninterruptible Power Supply for servers are highly recommended. The costs presented in this Purchase Order are associated with DICOM-network-ready systems. They do not include any new infrastructure fees for hardware or service such as network design or implementation, integration or installation costs of hubs, routers, Ethernet drops, or wide area network. These items are customer supplied, unless otherwise negotiated. New infrastructure elements can be supplied after engineering review and/or in-depth technical discussions with technical point-of-contact at customer site.

**Connectivity** This proposal is based upon the Buyer's representation that all imaging equipment installed at the Buyer's location(s) is DICOM v 3.0 compliant AND READY. The quoted system supports DICOM connectivity with eRAD PACS and up to the specified number of validated DICOM devices located at the Buyer's site and as further described on the attached Site Survey. These devices include, but are not

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 Confidential Page 4 of 7 9/23/2013

limited to: various imaging modalities, PACS and/or independent workstations. Any validated DICOM modality connected to the PACS network, post-original installation, shall be charged at the then-prevailing connectivity rate. eRAD PACS shall not be responsible for adverse effects of post original installation connections performed by someone other than eRAD PACS. Connecting a non-validated modality shall be charged at an hourly rate plus the connectivity fee. Prior to original installation eRAD PACS will inform the Buyer as to the existence of any non-validated modalities. It is the Buyer's responsibility to notify eRAD PACS of the identity of post-original installation modalities to determine their validation status. Connection to laser cameras will require the availability of a DICOM print-compliant camera.

**Firewall Protection** eRAD PACS utilizes 128-bit encryption, secure socket layer (SSL) is used to secure Patient Health Information. However, a firewall is recommended to protect the LAN and devices on the network.

### TERMS

**Validity of Quotation** This eRAD PACS proposal is valid for the period stated on the top of this quote. Acceptance of this quotation and receipt of first payment installment will initiate system order, manufacturing and installation scheduling.

**Delivery** Delivery is scheduled to be made Sixty (60) days or less from the acceptance of the order and receipt of the initial payment. Equipment is F.O.B. Greenville, S.C.

**Terms of Payment** See Final Page of the Above Quotation. In the event the annual study volume is exceeded, the upgrade of the license to the next appropriate level is immediately due and payable. Shipping and Sales Tax, if applicable, is NOT included.

### SOFTWARE LICENSE

**License** eRAD, Inc. hereby grants Buyer a perpetual, non-assignable and non-transferable non-exclusive License for the eRAD PACS, PracticeBuilder123® Software and Documentation, solely for use by it and its authorized users, subject to the terms and conditions contained herein and pursuant to the Purchase Order. Buyer and its authorized users agree not to allow the use of software by any person, corporation, or business entity other than as licensed or permitted herein. Buyer shall be responsible for each authorized user's compliance with the terms and conditions of this Agreement. Any changes to the system by customer without notification to eRAD will invalidate system licenses

**Permitted Uses and Restrictions** Buyer and its Authorized Users expressly acknowledge that the right to use any of the Software is granted only for use by Buyer and its authorized users and only for furtherance of Buyer's and its authorized users' business. There are no express or implied third party beneficiaries of this Agreement, including, without limitation, authorized users and patients of Buyer or any authorized user. No license is granted to directly or indirectly sublicense the Software. Without limiting the generality of the foregoing, Buyer and its authorized users are expressly prohibited from, directly or indirectly, licensing, marketing, selling, transferring, sublicensing, donating, assigning or commercially exploiting the Software licensed under this Agreement to third parties, whether or not for payment (including but not limited to, the operation of a service bureau environment, data processing services, commercial time sharing, rental or other similar sharing arrangements for a third party). Any such actions without eRAD's written approval will, without limiting any other available remedies, void the performance warranties contained herein, in the Purchase Order and in any Extended Warranty Agreement. Buyer and its authorized users may not modify, distribute, transfer, rent, timeshare, unbundle, create derivative works of, reverse engineer, decompile or disassemble the Software. Any such actions without eRAD' written approval will, without limiting any other available remedies, void the performance warranties contained herein, in the Purchase Order and in any Extended Warranty Agreement. Use as

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Confidential Page 5 of 7 9/23/2013

other than an image management system or any modification of the system configuration as specified in the Quotation, without the express written approval of eRAD PACS, shall cause this license to be forfeited and shall invalidate all warranties. As such, the expansion of the quoted configuration to include additional sites and/or additional modalities must be evaluated and expressly approved by eRAD PACS to insure that peak system performance is maintained.

**Monitoring and Additional Licenses** Buyer understands and agrees that eRAD will periodically monitor Buyer's licensed usage to ensure that the number of software processes and/or users licensed to Buyer solely for use by Buyer and its authorized users (as reflected in the Purchase Order) is consistent with Buyer's and its' authorized users' usage. Based on the results of the monitoring process, if additional license fees are due and payable to eRAD based on an increase in the number of processes and/or users or in, then eRAD will notify Buyer and/or Reseller in whose name the Purchase Order is entered of the results and Buyer will license additional processes and/or users or to bring Buyer into compliance with the terms of this Agreement. Moreover, Buyer further understands and agrees that eRAD will have unencumbered access to the Software for such monitoring purposes, and that at no time will Buyer or any authorized user disengage and/or alter any such monitoring devices and/or mechanisms so implemented by eRAD.

**Unauthorized Modifications** The hardware supplied with this Purchase Order has been approved by eRAD and configured specifically to operate the Software. Software configuration changes require approval and guidance from an Authorized Support Engineer. Authorized Support Engineers include appropriate personnel from eRAD and/or the eRAD Certified Dealers that sold the system. Any configuration changes made without eRAD' written approval will, without limiting any other available remedies, void the performance warranties contained herein, in the Purchase Order and in any Software Maintenance Agreement. Any support time incurred to reconfigure the system due to unauthorized changes will result in charges at the eRAD current hourly rates.

**Title and Copyright** All title, including but not limited to copyrights, in and to the Software and any copies thereof are owned by eRAD or its suppliers. All title and intellectual property rights in and to the content which may be accessed through use of the Software is the property of the respective content owner and may be protected by applicable copyright or other intellectual property laws and treaties. All rights not expressly granted are reserved by eRAD. All modifications to the Software developed by eRAD, with or without Buyer's or its authorized users' assistance shall be the exclusive property of eRAD.

**Export Restrictions** The Software is subject to U.S. export jurisdiction. You agree to comply with all applicable international and national laws that apply to the Software, including the U.S. Export Administration Regulations, as well as end-user, end-use and destination restrictions issued by U.S. and other governments

#### **LIMITED WARRANTY**

**Warranty** Installed software is warranted to perform to the specifications listed at the time of your purchase. eRAD will provide all upgrades to the software that are generally made available to its customers at no additional costs. These include any enhancements necessary to maintain the functionality requested in the purchase order.

#### **Warranty Exclusions**

This Limited Warranty does not cover:

- Hardware malfunction or defect. Unless otherwise explicitly stated herein, warranties on hardware. .
- External causes such as accident, abuse, misuse, or problems with electrical power.

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*Confidential Page 6 of 7 9/23/2013*

- Servicing not authorized by eRAD.
- Usage that is not in accordance with product instructions.
- Failure to follow the product instructions.
- Problems caused by using accessories, parts or components not supplied or approved by eRAD.
- Products for which eRAD has not received payment.

**Warranty Term** This limited warranty lasts for ONE YEAR from 30 days after final delivery or first clinical use, whichever comes first, unless you opted to purchase an extended warranty. (See Invoice or Purchase Order)

**Transfer of Warranty** Limited warranties on systems may be transferred if the current owner transfers ownership of the system and records the transfer with eRAD, Inc.

**Contact Information** To obtain pacs technical support, limited warranty or extended warranty service, Contact RPS Imaging at 1815 Washington Street Michigan City, IN 46350 or 1.800.710.4200 from 8 AM to 4:30 PM Local Time.

**THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS, WHICH VARY FROM STATE TO STATE (OR JURISDICTION TO JURISDICTION). eRAD's RESPONSIBILITY FOR MALFUNCTIONS AND DEFECTS IS LIMITED TO REPAIR AND REPLACEMENT AS SET FORTH IN THIS WARRANTY STATEMENT. ALL EXPRESS AND IMPLIED WARRANTIES FOR THE PRODUCT, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES AND CONDITIONS OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN TIME TO THE TERM OF THE LIMITED WARRANTY PERIOD REFLECTED HEREIN. NO WARRANTIES, WHETHER EXPRESS OR IMPLIED, WILL APPLY AFTER THE LIMITED WARRANTY PERIOD HAS EXPIRED. SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THIS LIMITATION MAY NOT APPLY TO YOU. WE DO NOT ACCEPT LIABILITY BEYOND THE REMEDIES PROVIDED FOR IN THIS LIMITED WARRANTY OR FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, ANY LIABILITY FOR THIRD-PARTY CLAIMS AGAINST YOU FOR DAMAGES, FOR PRODUCTS NOT BEING AVAILABLE FOR USE, OR FOR LOST DATA OR LOST SOFTWARE. OUR LIABILITY WILL BE NO MORE THAN THE AMOUNT YOU PAID FOR THE PRODUCT THAT IS THE SUBJECT OF A CLAIM. THIS IS THE MAXIMUM AMOUNT FOR WHICH WE ARE RESPONSIBLE. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATION OR EXCLUSION MAY NOT APPLY TO YOU.**

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 Confidential Page 7 of 7 9/23/2013



BACHELOR OF SCIENCE IN MEDICAL IMAGING  
FOUR YEAR CURRICULUM SEQUENCE

Fall Year 1	credits
BIOL 20300 A&P	4
CHM 10400 Living Chem	3
COM 11400 Fnd Speech	3
ENG W131 Eng Comp	3
MA 15300 Alg & Trig	3
<b>Total Credits:</b>	<b>16</b>

Spring Year 1	credits
BIOL 20400 A&P	4
NURS 10600 Med Term	3
PHYS 22300 X Ray Phys	3
PSY 12000 Elem Psy or SOC S161 Prin of Soc	3
STAT 12500 Comm w Stat	3
<b>Total Credits:</b>	<b>16</b>

Summer Year 1	credits

Fall Year 2	credits
RADX R105 Orient Rad	2
RADX R106 Pt Care	2
RADX R111 Rad I w Lab	3
RADX R270 Rad Physics	3
Gen Ed Elective	3
<b>Total Credits:</b>	<b>13</b>

Spring Year 2	credits
RADX R190 Intro Clin Ed	3
RADX R211 Rad II w Lab	3
RADX R271 Fnd Img Acq	3
RADX R304 Cros Sec Anat	3
<b>Total Credits:</b>	<b>12</b>

Summer Year 2	credits
RADX R191 Clin Ed I	2
<b>Total Credits:</b>	<b>2</b>

Fall Year 3	credits
RADX R192 Clin Ed II	3
RADX R215 Med Img Mod	3
RADX R255 Rad Bio/Prot	3
RADX R305 Rad Img Crit	3
Gen Ed Category B7	3
<b>Total Credits:</b>	<b>15</b>

Spring Year 3	credits
RADX R291 Clin Ed III	3
RADX R206 Adv Pt Care	2
RADX R306 Rad Path	3
RADX R371 Adv Img Acq	3
PHIL 11100 or 31200	3
<b>Total Credits:</b>	<b>14</b>

Summer Year 3	credits
RADX R292 Clin Ed IV	2
<b>Total Credits:</b>	<b>2</b>

Fall Year 4	credits
RADX R293 Clin Ed V	3
RADX R401 Legal Issues	3
RADX R410 PACS/RIS	3
RADX R450 QM	3
RADX R451 Prin CT	3
<b>Total Credits:</b>	<b>15</b>

Spring Year 4	credits
RADX R391 Clin Ed VI	3
RADX R310 Seminar Rad	3
RADX R320 Prof Dev	3
RADX R400 Leadership	3
RADX R481 Capstone	3
<b>Total Credits:</b>	<b>15</b>