RAD 1126

IMAGE PRODUCTION AND EVALUATION I
COURSE OUTLINE/INSTRUCTIONAL OBJECTIVES

Fall 2019
Professor E. Lobel, MA, RT(R)(CT)
ELobel@citytech.cuny.edu

Note: All other course related documents can be found on Blackboard.
New York City College of Technology/CUNY
Department of Radiologic Technology & Medical Imaging

Fall 2019

COURSE: RAD 1126 - Image Production & Evaluation I
1.5 cl hrs, 1.5 lab hrs, 2 cr (Fall Only)

INSTRUCTOR: Professor E. Lobel
OFFICE: Room A414

EMAIL ADDRESS: elobel@citytech.cuny.edu
PHONE: (718) 260-5360

OFFICE HOURS: 10:00 – 11:00 Tuesday 2:15 – 3:15 Tuesday

COURSE DESCRIPTION:
A study of the basic technical procedures and equipment used in medical radiography and fluoroscopy, including digital processing, relationship of exposure factors, and evaluation of radiographic quality.

PREREQUISITES COURSES: CUNY proficiency in reading, writing and mathematics. Courses: ENG 1101, BIO 1101, BIO 2311, MAT 1275 or higher, RAD 1124

COREQUISITE COURSES: RAD 1125, RAD 1127, RAD 1128, BIO 2312

NOTICE TO STUDENTS: Qualified students with disabilities, under applicable federal, state, and city laws, seeking reasonable accommodations or academic adjustments must contact The Center for Student Accessibility for information on CityTech’s policy and procedures to obtain such services. Students with questions on eligibility or the need for temporary disability services should also contact the center at: The Center for Student Accessibility, 300 Jay street, room L-237 718- 260-5143. HTTP://www.citytech.cuny.edu/accessibility/

GENERAL COURSE REQUIREMENTS:
The student will:

1. Utilize mathematical formula to adjust technical exposure parameters with varied patient situations.
2. Learn to differentiate between exposure parameters in order to balance patient dose vs. image quality
3. Identify structural anatomical differences between tissue types and apply the adequate level of radiation to yield diagnostic brightness and contrast.
4. Present their opinion when requested to choose the best quality image from several images with distinct problems.

**LEARNING OUTCOMES:** There are specific learning outcomes stated toward the back of this document pertaining to the lecture given for each weekly session.

**REQUIRED TEXT:**

**RADIOGRAPHY IN THE DIGITAL AGE: Physics - Exposure - Radiation Biology (3rd Ed.)**
By [Quinn B. Carroll](#) Published 2018 (3rd edition)

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**RECOMMENDED WORKBOOK FOR STUDYING:**

Student Workbook for Radiography in the Digital Age
Quinn B. Carroll
3rd Publisher CCThomas


**COURSE REQUIREMENTS & ASSESSMENT:** 1.25 hours of lecture and 1.25 hours of laboratory practice each week for 14 weeks, with reading assignments and written homework will be included. Along with quizzes, a midterm and a cumulative final exam will also be given on the seventh & fifteenth weeks, respectively.
COURSE GRADING:

Lecture and laboratory quizzes 20%
Midterm examination 25%
Final examination 45%
Participation 10%

Active Class Participation: Students are expected to participate in all classes and class activities through discussion, inquiry and individual or group activities both in the classroom and in the laboratory sessions.

Note: No quizzes will be deducted.

LATENESS POLICY: Lateness to the individual class sessions should be kept to a minimum. Lateness can prevent a student from completing course quizzes, as these will be given at the beginning of the lecture. Lateness will affect your level of class participation.

CLASSROOM CONDUCT:
- No Cellular phone interruptions during class (Turn off before class).
- No talking during instructor’s lectures or when another student is speaking.
- Food and drinks are not allowed in the classroom at any time.
- Cheating on examinations or an act of collusion are grounds for dismissal

NEW YORK CITY COLLEGE OF TECHNOLOGY POLICY ON ACADEMIC INTEGRITY:

Students and all others who work with information, ideas, texts, images, music, inventions and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the college recognizes its responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion. The complete text of the College policy on Academic Integrity may be found in the catalog.

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RAD 1126 Course Learning Outcomes

I. The X-ray Tube

1. List the three essential conditions for the production of x-rays, and how each is met.
2. Explain why the creation of a space charge around the filament through the process of thermionic emission makes the x-ray tube more efficient.
3. Describe the materials and construction of the cathode.
4. Describe two ways a repulsive charge on the focusing cup can be used.
5. Distinguish between the purpose of the filament current and the high-voltage current.
6. Explain why the x-ray tube has 3 wires connected to one end and only one on the other end.
7. Describe the materials and construction of the anode.
8. For the target surface, the anode disc, and the anode stem, state whether its electrical conductivity is high or low, and whether its heat conductivity is high or low.
9. Explain the purpose of spinning the anode at high speed.
10. Describe how the copper cylinder of the anode shaft acts as the rotor of the induction motor.
11. Explain the effects of the mA station, the filament selected, and focal spot blooming on heat dissipation and image quality.
12. Describe the function of the glass envelope of the x-ray tube.
13. List the causes of x-ray tube failure, both for the filament and for the anode.
14. Calculate the heat unit load for single-phase and 3-phase x-ray machines.
15. Properly interpret x-ray tube rating charts and cooling charts.
16. List ways of extending x-ray tube life.
II. X-ray Production

1. Describe the tremendous kinetic energies and speeds of the electron stream in the x-ray tube.
2. Describe the Bremsstrahlung interaction, its effect on the x-ray beam spectrum, and its impact upon the image.
3. Describe the Characteristic interaction, its effect on the x-ray beam spectrum, and its impact upon the image.
4. Given the binding energies of various atomic “shells,” calculate the energy of characteristic x-rays resulting from different exchanges of electrons between them.
5. Sketch an accurate representation of the x-ray beam spectrum including both bremsstrahlung and typical characteristic x-rays.
6. Describe the poor efficiency of x-ray production.
7. Describe the effects of target material, mAs, filtration and kVp and the type of generator used upon the x-ray beam spectrum.

III. Creation of the Image
1. Define the parts of the x-ray beam.
2. List and give examples of the six general types of radiographic variables affecting the image.
3. Describe the photoelectric effect, its occurrence, and its impact upon the “latent” image carried by the remnant x-ray beam.
4. Describe the Compton effect, its occurrence, and its impact upon the “latent” image carried by the remnant x-ray beam.
5. Given the energy of an incoming x-ray photon and the binding energy of an electron shell, calculate the kinetic energy of the ejected electron and energy of any scattered x-ray for the photoelectric and Compton interactions.
6. Quantify the typical energy of a scattered x-ray photon as a function of its angle of deflection.
7. State the implications for the angle of scatter deflection and energy both for exposure at the image receptor and for backscatter exposure to personnel.
8. Describe the results of characteristic interactions within the patient.
9. Explain the exponential attenuation of the x-ray beam through thicknesses of tissue.
10. Apply the “4-centimeter” rule.
11. Explain the necessity of subject contrast in the remnant beam signal, and the role of differential absorption in producing it.
12. Describe how very thin layers of detective material at the image receptor can absorb x-rays effectively to produce an image.

IV  Production of Subject Contrast

1. Define subject contrast and quantify how it is altered by changes in tissue that result in different ratios of interactions.
2. Give a clear mathematical approach for measuring subject contrast.
3. Quantify the effects of tissue thickness, physical tissue density, and tissue atomic number on the production of subject contrast in the remnant beam signal.
4. Specify the effects of scatter radiation on subject contrast in the remnant beam signal.
5. Describe the effect of increasing kVp upon the predominance of Compton and photoelectric interactions, and the resulting impact on the image.
6. Describe the effect of increasing the atomic number of tissue or contrast agents upon the predominance of Compton and photoelectric interactions, and the resulting impact on the image.
7. Distinguish between the production of Compton interactions and the amount of scatter radiation reaching the image receptor, and why kVp is a relatively minor influence on subject contrast when compared with field size and part thickness.
V  Visibility Qualities of the Image

1. List and define the three visibility components of every image.
2. Describe the effects on details for both excessive contrast and insufficient contrast.
3. Identify the best level of brightness (density) for a radiograph, and why sufficient penetration of the x-ray beam is critical to achieve it, especially when contrast agents are used.
4. Define radiographic contrast and gray scale, and how they interrelate.
5. Demonstrate that brightness and contrast are independent of each other as image qualities.
6. Define radiographic noise and give examples.
7. State the two ways that the signal-to-noise ratio (SNR) can be improved.
8. Define artifacts and give examples.

VI  Geometrical Qualities of the Image

1. List and define the three recognizability or geometrical components of every image.
2. Define image sharpness or spatial resolution.
3. Define and describe the cause of geometrical penumbra.
4. Calculate radiographic penumbra or unsharpness for variable distances and focal spots.
5. Calculate the relative sharpness for different distances.
6. Distinguish between poor contrast and poor sharpness.
7. Distinguish between the effects of blur and magnification on a penumbra diagram.
8. Calculate the magnification factor for variable distances.
9. Define and quantify shape distortion, as distinct from magnification.
10. Define overall image resolution, and list its two primary components.
1. Describe what mAs controls in the x-ray beam, and distinguish between the proper units for x-ray beam intensity and electrical current intensity.
2. Describe why mAs is considered the *primary control* for exposure.
3. Calculate the total mAs for various combinations of mA and exposure time, and vice versa.
4. Develop the ability to do simple mAs calculations mentally.
5. Explain the root causes of quantum mottle or scintillation, and how to correct it.
6. List those image qualities which are *not* directly affected by mAs.
7. Accurately explain the relationship between exposure time and motion unsharpness.
1. Describe what kVp controls in the x-ray beam, and distinguish between the proper units for x-ray beam penetration and electrical force.
2. Describe the relationship between increasing beam penetration and subject contrast in the remnant beam signal.
3. Define the minimum kVp for a body part, and what determines it.
4. Explain why increases in x-ray intensity (mAs) cannot compensate for insufficient penetration (kVp).
5. Distinguish between the effects of increased kVp on x-ray tube output and on the remnant x-ray beam reaching the image receptor.
6. Accurately calculate proper mAs compensations for various kVp changes using the 15% rule.
7. Define optimum kVp for digital imaging, and how it differs from minimum kVp.
8. Describe how the 15% rule can be used to advantage in lowering patient exposure.
9. Rank kVP against body part thickness and field size as a contributor to scatter radiation.
10. Explain why much higher kVp's can be used with digital imaging than used to be used for film radiography.
11. List those image qualities which are not directly affected by kVp.
IXA - Generators and Filtration

1. Explain the effects of higher power generators upon effective mA and effective kV.
2. State the appropriate reductions in radiographic technique for higher power generators.
3. List the image qualities that are affected by generator power, and those not affected.
4. State the minimum filtration requirement for x-ray machines operating above 70 kVp.
5. Describe the purpose of protective filtration, and what limits the amount used.
6. List the two types of protective filtration and give examples.
7. Define half-value layer (HVL) and how it is measured.
8. List the three determining factors for x-ray beam penetration and “hardening of the beam.”
9. Describe the purpose of compensating filters and where they might still be of value with digital procedures.

Field Size Limitation

1. State the major guidelines for determining proper field size.
2. Quantify how effective field size limitation can be in reducing organ dose.
3. Define off-focus radiation and which collimating devices are most effective at reducing it.
4. Describe the history and proper use of positive beam limitation (PBL).
5. State the risks associated with over-collimation, and the guideline to avoid clipping anatomy.
6. Explain how a larger field size contributes to scatter production, and why subject contrast is reduced.
7. Explain how a larger field size contributes to overall exposure level at the IR.
8. List those image qualities that are not affected by field size.
9. For various distances and apertures, calculate the resulting field size, and vice versa.
1. Describe the proper locations and methods for measuring body part thicknesses.
2. Explain why radiographic technique can be approached in a systematic and scientific way.
3. State the average thicknesses for the adult torso in AP and lateral projection.
4. Use the 4-centimeter rule to derive appropriate techniques for variable part thicknesses.
5. State the rule for minimum change of exposure factors.
6. Describe each of the five types of body habitus and the associated adjustments for technique.
7. Describe the influence of age and anthropological factors on radiographic technique.
8. List the five general types of materials that are radiographically demonstrable, in order from most radiolucent to most radiopaque.
9. Describe the impact of the molecular (average) atomic number and physical density of body tissues upon subject contrast in the image.
10. Describe the impact of the molecular (average) atomic number and physical density of contrast agents upon subject contrast in the image.
11. Describe the effects of patient cooperation and stage of respiration on chest radiographs.
12. Define radiographically additive and destructive diseases.
13. For the most common additive and destructive diseases, describe the appropriate types of adjustments in radiographic technique.
14. State the technique guidelines for post-mortem radiography.
15. State the technique guidelines for soft-tissue radiography.
16. State the technique guidelines for cast and splint radiography.
1. Prioritize the causes of scatter radiation by their degree of influence.
2. Understand the nominal role of high kVp levels in image degradation, especially for digitally-processed images.
3. Distinguish between the visibility effects of scatter radiation and the geometrical effects of blur, and that they are not directly related to each other.
4. Describe the geometry of how grids eliminate scatter radiation from the remnant beam.
5. Define grid ratio, describe how it improves subject contrast in the remnant beam, and explain why it is the only reliable method of indicating the effectiveness of a grid.
6. Calculate the grid ratio from grid dimensions.
7. Define grid frequency and lead content, and explain why they are not reliable ways of indicating grid effectiveness.
8. Describe the role of grids for digital imaging.
9. Prioritize part thickness, field size and set kVp in determining grid use and appropriate grid ratio.
10. Define the bucky factor and selectivity of a grid.
11. State technique compensations for landmark grid ratios and from tabletop to bucky.
12. List those image qualities not affected by grids.
14. State the cut-off effects of distances outside the grid radius for focused and parallel grids.
15. State the cut-off effects of off-centering or off-angling the x-ray beam and grid crosswise to the grid strips.
16. Describe grid line patterns and the directions one can off-center or angle the x-ray beam without causing cut-off effects.
XIII The Anode Bevel and Focal Spot

1. Describe how the line-focus principle is used to allow for high image sharpness while providing for adequate heat dispersion at the anode surface.
2. State how the line-focus principle causes the image to be sharper at one end of the field than the other.
3. Describe the cause of the anode heel effect, and the factors that make it worse.
4. For different body parts of variable thickness, state the best end of the x-ray table to position the patient’s head end, in order to minimize the anode heel effect.
5. Quantify the relationship between focal spot size and image penumbra.
6. Explain why geometrical penumbra occurs.
7. Explain how the umbra portion of the image can be made to completely disappear.
8. Describe why magnification is not affected by the focal spot size.
9. Describe why the focal spot is uniquely considered as the controlling factor for sharpness.