Hands-on Physics Teaching of Radiology Residents

Jie Zhang, PhD, DABR
Associate Professor, Chief
Division of Medical Physics, Department of Radiology
University of Kentucky

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Teaching physics to radiology residents

- A Challenge

- Limited physics background
  - Most residents majored in Biology, Chemistry, etc.
- Lack of motivation
  - Learn sufficient physics to pass ABR exam
- Limited time
  - Many clinical demands on their time

ABR exams

- **Core Exam (Qualifying Exam):**
  - to validate if the candidate has acquired the knowledge, skills, and understanding basic to the entire field of diagnostic radiology, including physics.
- **Certifying Exam:**
  - to validate if the candidate has acquired and is able to **apply** the requisite knowledge, skills, and understanding that every practicing physician and radiologist should possess to begin independent practice.

"put into action"

The ABR Examinations stress integration of physics into real-life clinical practice

passive recall of facts (hearing, seeing)

active applications of physics principles (acting)

Hearing → **Seeing** → **Interactive** → **"Put into action"**

Didactic Lecture

Observation

ABR Goal

Active application of physics principles

不闻不若闻之，闻之不若见之，见之不若知之，知之不若行之；学至于行之而止矣。

----- **荀子**, *Xunzi,* a 3rd century BC philosopher and teacher

*I **hear** and I **forget**.*

*I **see** and I **remember**.*

*I **do** and I **understand**.*

true learning continues until it is put into action

A "hands-on" approach to teach physics

- Engages the learners, viewed as eminently practical
- Provides "Psychological intervention"
  - Convert a negative interpretation into a positive or neutral interpretation that leads to greater success and a sense of belonging in the classroom

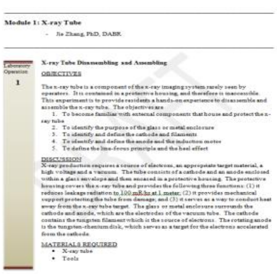
Physics hands-on rotation

- One-week physics rotation for first year residents before didactic physics lectures
- 7 Modules

Day 1	Day2	Day 3	Day 4	Day 5
X-ray Tube	Fluoroscopy	Nuclear Medicine	MRI	Ultrasound
Radiography/ Mammography	CT	SPECT/PET	MRI	Safety and wrap-up

Curriculum for hands-on physics education

- X-ray tube component, output and heel effect
- Effects of imaging acquisition i.e., kV, mAs, focal spot size, SID, field of view, on image quality and radiation dose
- Appropriate use of AEC
- Fluoroscopy and CT dose metrics and measurements
- Strategies to reduce patient and personnel dose
- Tube current modulation and auto kV
- Ultrasound image creation and Doppler
- T1, T2, FID, MRI scanner component, MRI safety
- Dose calibrator and radiation survey, gamma camera and SPECT
- PET principle



Module 1: X-ray Tube

- Jie Zhang, PhD, DABR

Laboratory Operation 1

X-ray Tube Disassembling and Assembling

OBJECTIVES

The x-ray tube is a component of the x-ray imaging system rarely seen by operators. It is contained in a protective housing, and therefore is inaccessible. This experiment is to provide residents a hands-on experience to disassemble and assemble the x-ray tube. The objectives are

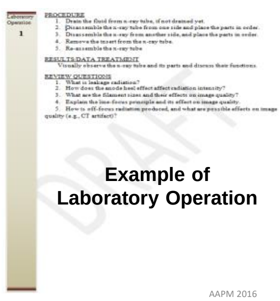
1. To become familiar with external components that house and protect the x-ray tube
2. To identify the purpose of the glass or metal enclosure
3. To identify and define the cathode and filaments
4. To identify and define the anode and the induction motor
5. To define the line-focus principle and the heel effect

DISCUSSION

X-ray production requires a source of electrons, an appropriate target material, a high voltage and a vacuum. The tube consists of a cathode and an anode enclosed within a glass envelope and then encased in a protective housing. The protective housing covers the x-ray tube and provides the following three functions: (1) it reduces leakage radiation to 100 mR/hr at 1 meter; (2) it provides mechanical support protecting the tube from damage; and (3) it serves as a way to conduct heat away from the x-ray tube target. The glass or metal enclosure surrounds the cathode and anode, which are the electrodes of the vacuum tube. The cathode contains the tungsten filament which is the source of electrons. The rotating anode is the tungsten-rhenium disk, which serves as a target for the electrons accelerated from the cathode.

MATERIALS REQUIRED

- X-ray tube
- Tools



Laboratory Operation 1

PROCEDURE

1. Drain the fluid from x-ray tube, if not drained yet.
2. Disassemble the x-ray tube from one side and place the parts in order.
3. Disassemble the x-ray from another side, and place the parts in order.
4. Remove the insert from the x-ray tube.
5. Re-assemble the x-ray tube

RESULTS/DATA TREATMENT

Visually observe the x-ray tube and its parts and discuss their functions.

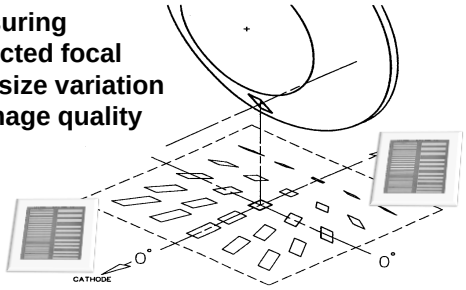
REVIEW QUESTIONS

1. What is leakage radiation?
2. How does the anode heel effect affect radiation intensity?
3. What are the filament sizes and their effects on image quality?
4. Explain the line-focus principle and its effect on image quality.
5. How is off-focus radiation produced, and what are possible effects on image quality (e.g., CT artifact)?

Example of Laboratory Operation

X-ray tube disassembly

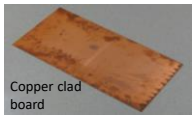
Measuring projected focal spot size variation on image quality



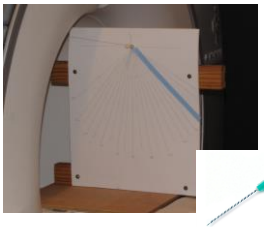
Measuring CTDI

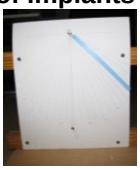
Experiencing force on metal

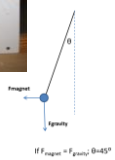
Feeling eddy current



Assessing safety of implants







Summary

- Covers basic physics concepts, specifically targeting their clinical uses through interactive practice.
- Makes theoretical physics concepts “real” .
- Prepares residents for deep understanding of physics from didactic lectures

Residents' feedback

I was surprised by how applicable the understanding of physics is to the diagnostic radiologists daily practice.

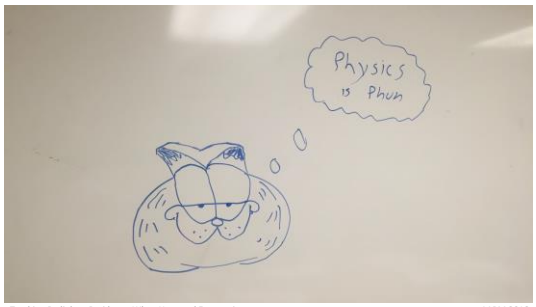
It has gotten me familiar with lots of the basic concepts I will encounter during this first year. It's given me a good baseline to start from and also encouraged me to try to build my physics knowledge early on. Rather than just viewing it as another part of the CORE I think it's helped me see how critical it can be to making me a better radiologist.

Lessons Learned

- Be prepared
  - Practice before hands-on rotation
  - Ensure scanner availability

Next step

- Solicit feedback from radiologists, technologists, residents, colleagues
- Evaluate outcome of hands-on physics training
  - ABR Core Exam: Physics score
  - Radiologists' observation during clinical rotations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