**Fluoro Test Review**

The practice test questions are not repeated verbatim on the exam. They are only slightly helpful for the test. I would primarily look at the 6 page outline of the topics which appears in the thick packet with the green front page you should have received in the mail. If you know those topics well and you read up on them in the longer syllabus you will be doing well. Beware that not all topics are covered in the syllabus, you will have to google them, i.e. DICOM, HIS, RIS, etc.

**hopefully you won’t have to google much...I have included the results of all my google-ing...some stuff I skipped or didn’t find...if you find additional stuff add it to this and pass it on, anything in red is directly asked, most of the other stuff is also on their in some form or another...also, there is definitely a lot of stuff on the test I wouldn’t have found unless I went through the process of making this, so just know that doing some reading on the internet is helpful***

**Useful resources**

- Review of Radiologic Physics (book on Lane library website)
- Useful websites
  - [http://www.studystack.com/flashcard-550700](http://www.studystack.com/flashcard-550700)
    - click on the fluoro review sample exam
  - Google search in the google books section..put in “radiography” and then whatever
- Of the tests on the Stanford Ortho website, I’d completely skip “Fluoro Exam 1”...it doesn’t have answers so who knows if it’s right...Fluoro Exam 2 has 1 test that has an answer sheet about half way through the document and also a 15-20pg outline which is helpful....so of the Stanford resources I’d use the Fluoro Syllabus and Fluoro Exams 2 document.

**Stuff I didn’t know not answered in this outline...**

- make sure you have the difference between photons and electrons involved in quantum mottle...answers are either in units of photons or electrons and I didn’t know which
- figure out how window level and width works...the answer is either about brightness or contrast
Topics

**Digital subtraction angiography** Images of arteries are taken before and after contrast injection; then a computer subtracts one image from the other. Images of structures other than arteries are thus eliminated, enabling the arteries to be seen more clearly. **you need to know more detail than this...i forget what**

**Moire effect (Aliasing):** a grid error that occurs w/digital image receptor systems when grid lines are captured and scanned parallel to scan lines in the image plate reader (i think like when scanned into the XR reader machine when scanning into PACS). Grid lines usually run parallel to the long axis of the image plate and then are scanned along the short axis (which would mean it’s scanned perpendicular to scan lines and the Moire effect does NOT happen)...it does occur for exams like portable XR and translateral hip images.

mask substitution (?)

**window level and width function effects:** in imaging a range of voxel values is selected to determine shading function by defining a window width (the range) an a window level (voxel value of the center of the range) On one side the voxels are shaded dark and on the other they are shaded light....w/in this range the shading is stretch from light to dark using a certain function.

**spatial resolution:** refers to the smallest discernible brightness difference between two adjacent pixels or object details (the ability to resolve closely spaced objects aka detail) Measured w/phantom bars made of lead or acryllic referred to as “line pairs (LP)

**bit depth:** the bit indicates the number of possibilities for defining a grayscale value (from black to white)...ex: “8-bit depth is the number of exponents ($2^8 = 256$) possibilities of a grayscale value from black to white for the definition of a pixel...the greater the bit depth, the greater number of shades of gray available...12-bit depth is used in angiography

**Signal to Noise Ratio (SNR):** primary determinate of image quality referring to signal (useful info) to noise (crap such as scatter, background electrical interference)

Contrast to Noise Ratio (CNR)...can’t find specific definition, think its similar to SNR
**Had to choose 2 or 3 components of each:**
variables including dose report, ID info, modality, EMR etc

**HIS (hospital information system)**
- patient data entered on admission into the system

**RIS (Radiology Information System)**
- computerized database used by rads dept to store, manipulate and distribute patient images

**DICOM “Digital imaging and communication in medicine”**
- contain info specific to patient such as type of dig equipment, pixel data
- safeguarded to permanent altering of the image
- can be exchanged between systems

**PACS (Picture Archiving and Communication Systems) ...all above are related...see diagram below**
**Terminology, Principles, Radiation Artifacts**

1. **Source** = where XR comes from, **Object** = person/body part, **Image** = XR plate
2. **Object to Image Distance (OID):** practical rule of placing object/person as close to the image receptor (the XR plate) as possible...magnification occurs when not placed close...standard OID = 40 inches (100cm) which results in a magnification of 1.1...geometric blur/edge blur also increases as OID increases

3. **Source to Image Receptor Distance (SID):** greater SID will reduce geometric blur and improve recorded detail...has no effect on penetrating power of kVp and will not effect contrast as long as kVp remains unchanged.
4. **Source to Object Distance (SOD):**
5. **Focal Spot Size:** Large focal spots are favored when a short exposure time is important, and small focal spots are needed to obtain the best spatial resolution
6. **Kilovoltage (kVp):** determines the penetrating ability of XRs and refers to the quality of X-rays; so high kVp is generally better to reduce patient dose of radiation...BUT if it gets too high it creates scatter and then a loss of contrast
7. **Milliamperage (mA):** intensity of XR / quantity of radiation; radiation received is directly proportional to mA
8. **Anode strength** (size presumably): the anode accelerates electrons to the output phosphor...the target (which generates the XRs) is embedded within the anode...the target gets hit by an electron stream at the focal spot and then this creates the XR beam shot at the patient.
9. **Magnification:** Image size equals the object size x M (magnification factor)...a. \( M = \frac{\text{SID}}{\text{SOD}} \)
10. **Minification Gain:** increase in image brightness resulting from reduction in image size from the input phosphor to the output phosphor...equals the squared
ratio of the input screen to the output screen size

11. **Conversion Factor:** \( \text{ratio of luminance} \) of the output phosphor to the input exposure rate

12. **Units of Radiation Dose**
   a. \textbf{Rad} = ‘radiation absorbed dose’ = quantity
   b. \textbf{Rem} / \textbf{Sievert} take into account a quality factor (multiplier) that would have to be given
   c. **Conversions (all were in mSv on exam)**
      i. 1 Gray = 100 rads
      ii. 1 Sv = 100 Rems
      iii. 1 rad = 100 ergs / gram

13. **Distance:** \textit{intensity of radiation varies inversely with the square of distance}
   a. distance doubled = radiation reduced by \( \frac{1}{4} \)...tripled then reduced by \( \frac{1}{9} \)
   b. \((\text{Distance 1})(\text{Intensity 1})^2 = (\text{Distance 2})(\text{Intensity 2})^2\)

14. (quantum) **Mottle:** artifact caused by too few x-rays reach the detector or too much noise (high SNR) and appears as grainy or textured pattern...corrected by increasing kVp or, if background is also mottled, increase mAs

15. **Scatter**
   a. \textbf{Compton effect}: occurs when incoming XR photon is absorbed and then ejects an electron AND there is still enough energy to re-emit a secondary photon which is scattered in any direction causing a decrease in contrast / fog on the image or hitting you the fluoro operator...accounts for 99% of scatter
   b. \textbf{Thompson effect / classical or coherent scatter}: when XR hits and energy isn’t enough to fully eject an electron but rather bump it to a higher electron orbital --> when this electron falls back down it re-emits a photon which is the scatter

16. **Leakage**
   a. radiation transmitted through the XR tube housing
   b. shouldn’t exceed 100mR/hr at a distance of 1m from XR tube

17. **Attenuation**
   a. partial absorption of XR beam / reduction in intensity that occurs as it traverses the body part...thicker/denser the body part the greater the attenuation

18. **Grids**
   a. used to remove scatter, improves contrast
   b. made of narrow parallel bars of lead placed between pt and image receptor
   c. \textbf{increasing the grid ratio increases patient exposure}

19. **Cine**
   a. series of photospot images obtained in rapid sequence to make a video type effect
20. **Risk factors for nephrotoxicity**: multi myeloma v DM v renal insufficiency

MANY questions on ABC/AEC...still can’t quite figure out difference...

- **Automatic exposure control (AEC):** measures the dose of radiation that strikes the X-ray film behind the patient, and turns the X-ray system off when the predetermined dose for that screen-film combination has been reached. controls the time (length) of exposure.

- **Automatic brightness control (ABC):** keeps brightness of image constant at the monitor by regulating mA and kVp on the input phosphor. (not by messing w/exposure duration which is AEC) ex: when the fluoro is panned from thin to thick region of patient the image will get darker but this will be sensed by the system and thus the ABC will automatically increase the exposure rate (mA).

**Radiation Exposure Stuff**

- **Long Term Effects**
  - Somatic: cancer, fetus effects, cataracts
  - Genetic: maybe expressed in future generations?

- **Dose-Effect Curve**
  - Radiation guides are based on the assumption that there is a **non-threshold, linear dose-effect curve**...that is to say there is no minimal threshold which needs to be surpassed to have an effect and the more exposure the more likely an effect
    - except for non-stochastic effects like cataracts

- **Non-Stochastic Effect** --> health effect where its **severity** increases w/dose and a threshold is believed to exist --> cataracts

- **Stochastic Effect** --> health effect occurs randomly and the **probability of it happening** increases w/increasing radiation dose --> cancer

- **Fetus Facts**
  - 50 rads --> could lead to spontaneous abortion
  - **Timeline** for badness
    - **Weeks 1-2** --> spontaneous abortion
    - **Weeks 2-6** --> organ / morphological defects
    - **Late exposure** --> CNS, learning deficits
  - **10 day rule** --> when possible, avoid XR’ing a women of reproductive age in the 10 day interval following onset of menses

- **Cataracts**
  - lenses w/0.25mm lead-equivalence reduce exposure by 85-90%
  - dose required probably on order of **several hundred rads** acute dose
- example of a non-stochastic effect

  **Cancer**
  - early radiologists got skin CA and leukemia
  - radium dial painters got bone tumors
  - uranium miners got lung CA
  - Hiroshima victims got leukemia
  - Most frequent CA in descending order
    - breast (female)
    - thyroid
    - hemopoietic tissue
    - lungs --> GI --> bones

- **Skin Effects**
  - Erythema is first / early effect w/in 1-2 days after radiation

### Radiation Dose Limits

- seem to be tested in 3 different units... mSv, rem, or Sv... $1 \text{ Sv} = 1000 \text{ mSv}$ = *100 rem* so you can just convert

- **Max C-arm exposure rate** allowed 5 R/min

- **Occupational (whole body) exposure** (for people working w/radiation)
  - NCRP recs lifetime cumulative effective dose limit 10 x individuals age (mSv)
  - NCRP limit 50 mSv in any year = *5 rem = 0.05 Sv*
    - so should be less than 0.5 rem / month

- Public (for random people in the public)
- **Pregnant Workers**
  - NCRP recs limit 0.5 mSv/month (0.05 rem) /month to fetus which implies a total dose limit of 5 mSv (0.5 rem)
  - if fetus already received 5 mSv (0.5 rem) at the time pregnancy is declared, any additional dose must be below 0.5 mSv (0.05 rem)
- **Pregnant Public non-workers**
  - NCRP recs limit of total 1 mSv
- **Eye Lens**
  - Workers: 150 mSv / year limit = 0.15 Sv = 15 rem
  - Public: 15 mSv / year
- **Skin / Hands / Feet**
  - Workers: 500 mSv / year limit = 0.5 Sv = 50 rem
  - Public: 50 mSv / year
- In general limit for public is 1/10th of that of limit for occupational exposure

**XR Monitoring Devices**

- **Location**: should be worn on the collar above the lead apron
  - 2nd can be worn under in case of pregnancy to gauge dose reaching the fetus
- Changed monthly
- **Film badge**
  - cheap, most common used
  - reports dose in rems
- **Thermoluminescent Dosimeter**
  - more accurate and expensive
  - once exposure has been read the info is then lost
  - can be used over longer period of time
- **Pocket Ionization chamber**
  - disadvantages include no permanent record, periodically need calibration and sensitive to mechanical shock

**XR Protective Devices**

- **Bucky slot cover**
  - when tray is removed after exam the side of the table has a 2in opening at gonad level for the fluoroscopist called the Bucky Slot...it must be covered automatically...function to protect fluoror staff
  - minimum 0.25 mm lead equivalent
- **Protective curtains**
  - minimum 0.25 mm lead equivalent
- **Gonad Shield**
  - must be 0.5 mm lead equivalent
  - best is shaped contact shield worn in a cup type device
    - total gonad dose reduction for a 0.5mm shield is approx 92%
    (still don’t quite understand this...different %’s listed on
different sources)
- **Protective Apron/Gloves**
  - must be 0.25mm lead equivalent

**XR Production**

- XR tube filament heated which emits electrons
- high voltage applied between filament (cathode) and target (anode)
  - cathode = negative charge
  - anode = positive charge
- Electrons accelerated away from cathode toward anode
  - flow of electrons = current in mA
- Electrons hit the target the energy is converted to XRs
  - targets are made of molybdenum, tungsten, rhodium
- XR Spectrum
  - (A) Bremmsstrahlung XR are produced when energetic electrons interact w/nuclear electric fields and are decelerated...as they are decelerated the energy lost appears as a XR photon
    - most XR produced are via bremsstrahlung process
  - (B) Characteristic radiation: target electrons are ejected by incident energetic electrons

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![Diagram of XR production](image)
The Image Intensifier

- **Input Phosphor**
  - absorbs XR and converts to light photons
  - Size = 6 – 14 inches
- **Photocathode**
  - bonded to input phosphor
  - converts light photons to electrons (photoemission)
  - # of electrons directly proportional to intensity of XR hitting input phosphor
- **Electrostatic Lens**
  - rings along I.I. made to focus the electrons into a fine beam
- **Accelerating Anode**
  - accelerates focused electron beam to output phosphor
- **Output Phosphor**
  - receives electrons from photocathode converts them to light photons...
  - Size = 1 inch
  - it is much brighter than those at the input phosphor bc the electrons have been accelerated and the output phosphor compared to the input phosphor

Couple questions on cumulative timer, primary purpose, how it works

- **Cumulative manual-reset timer**: goes when the designed to protect pt and make fluoro operator aware; usually set to make a sound at 5 mins;

**Questions / Answers**

1. What % of scattered XR is blocked by 0.5 mm lead at 1 m at 90 degrees from source (choices: 90 or 100%)?
   a. 0.25mm lead --> transmitted exposure lessened by 97%
   b. 0.5mm lead --> transmitted exposure less by 99.9%
2. sterility: short or long term?
   a. “spermatogonia depleted by small amounts of radiation (30-50 rads)...sterility after is only temporary”
3. Which of these are important questions regarding allergies to contrast mediums: (hx of contrast: obviously, other medical allergies: think so, smoking: I said no)