

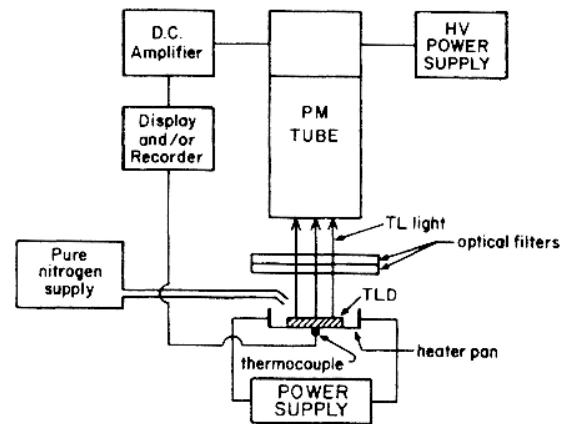
## 2009 ABR Part III – Oral Exam Type (Therapy)

### Comments:

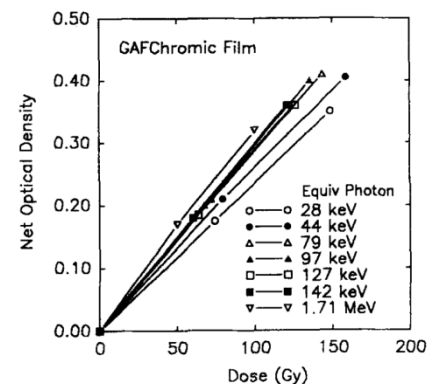
- I believe the exam was quite fair and very relevant in terms of content – as opposed to written, oral questions definitely require clinical experience to do a good job. Examiners also probe you (whenever they get a chance) to understand if you're directly familiar with what's being asked. Often I had questions such as "what do you read in the electrometer", "what are typical numbers for..." or "have you done that yourself" etc.
- Overall, I found the exam very fast paced – you can see from the list of questions below. This is something I wasn't expecting. I thought I would get a question like "describe your QA process for ..." or regulations etc and I was concerned that I would miss something in the long list of things... However, the questions were very direct and required quick/short answers. Even though the first question might seem broad, I was often interrupted by a follow up question when I was explaining something long. I wish I knew this before and wouldn't waste time worrying such that I would be screwed if I miss an item in a long list of procedures.
- I found the examiners generally aggressive but not intimidating. They just seemed to squeeze a lot of questions in (what it felt like a) short time. They were also helpful at times.
- Another observation about mentioning crucial reports/publications. I thought the examiners weren't very much interested in those; they wanted you to answer the question and see if you have done it. I tried to mention a report in two occasions when I felt stuck but I noticed chuckles in the examiners' face as if saying "that won't help you get out of this question". So I guess it wouldn't hurt to mention them but don't fool yourself into thinking that you'll score points by mentioning names of reports (TG XX etc.). Others might feel differently.
- Three of the five examiners were very nice; two showed no expression and kept trying to get me to change my answer. Before the exam starts they tell you that the examiners want you to pass and will help push you in the right direction; this is true to some extent and depends on the examiner. I found that if you don't sound confident in your answer, they will make you second guess yourself -whatever you do stick with your original answer

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- Two MRI (axial) slices of brain. What type of MRI is this (T2) – how do you know that? Are there other types? How is this image generated and what information does it give? Is contrast used in MRI? What material? How do you use this image in treatment planning? How does fusion work.
  - Find optic nerves, optic chiasm, frontal lobes, ethmoid sinus, nasal septum... find more structures (such as lateral ventricles, brainstem, sagittal sinus, falx cerebri and white matter) do you see any tumor on these images. What would we call that volume (define GTV, CTV and PTV). If it is a GBM do you know what GBM is? Would we treat edema surrounding tumor? Why?

- The TLD diagram from Attix (on right) Explain this and how you use TLDs in clinic  
What's annealing and its purpose? How do you do it in your clinic? Draw a glow curve  
Would reading a TLD 1 hr or 1 day from irradiation make any difference? How can you improve this (preheat) Pointing to the glow curve I've drawn, what does preheating actually do?  
What's the purpose of nitrogen gas?  
What's typical accuracy achievable with TLD?  
What do you actually read from TLDs and what are typical numbers?

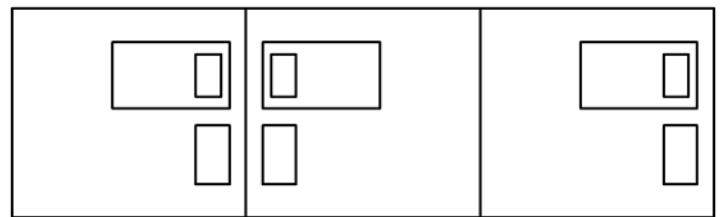


- Neutron shielding (no pictures) In what way neutrons present radiological hazard for linear accelerators How are neutrons produced – what's the energy threshold and when does it become a serious problem What locations and room designs, is it a problem – laminated vs. all concrete rooms How do you design a linac door? What are the energies of neutrons at door and BPE TVL? Why use Boron in BPE? Why not just use Boron alone then??? What's the door thickness of your linac room?
- Talk about stochastic and non-stochastic effects of radiation What are they, where do these models come from Give examples for both of these effects For non-stochastic asks the dose limits for cataract formation, sterility thresholds in males and females, kidney, lung, spinal cord dose limits.
- What's the model used in regulations, what are occupational and non-occupational dose limits – why are they different?
- Three images with adjacent electron and photon field isodose lines (field matching question) but no text is provided or any clues What do you think is being shown here What's the difference in the three pictures Give two examples of clinical sites you may do e+ph matching. How do you do field matching with electron and photon fields for these cases (geometry/design). What's another way of avoiding hot and cold spots in adjacent fields (other than junction shifts)
- H&D curves for radiochromic film (plot on right) Discuss radiochromic films. Differences from radiographic films, advantages and its disadvantages. Explain the energy dependence seen on the plot – why does it look like that? What elements are the radiochromic films are made of? How about radiographic films? Do you use radiochromic film in your institution? Radiographic film? What type? What's different between XV and EDR film? How would this plot (energy dependence) look for EDR film as compared to radiochromic?



- A rudimentary picture of a cylindrical ion chamber is given. Explain this, what type of ion chambers do you use what is central electrode, guard and wall is made of? What is the purpose of guard? How is this connected to triax cable?

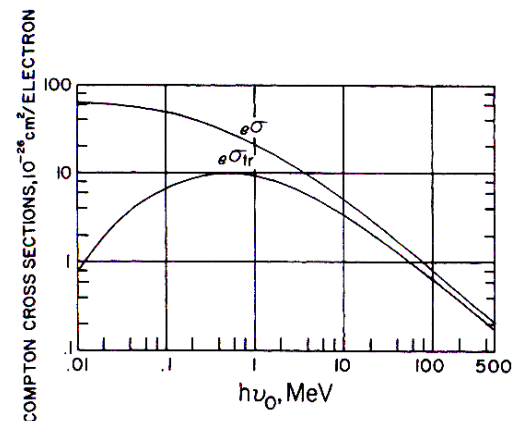
- Depth ionization curves for electron and photons is shown (with and without shifts overlaid) what are these plots, which one is electron and which one is photon (how did you identify) (Pointing to electron curve) is this a PDD curve? Why is PDI and PDD different for electrons? What do you need to use to convert it to PDD? Have you actually done that and how?
- How do you setup for electron TG-51 calibration? Can you use a different SSD if more convenient for you? What kinds of chambers are recommended?
- Picture of a klystron (a more elaborate drawing than simple diagrams on textbooks) What's this and how is it used? How does it amplify RF power? Show where the input and output RF directions. Is transmission guide filled? What's the purpose? How about accelerating guide? What's the frequency and wavelength of the RF waves? What happens if the frequency is doubled – how does it change the design of accelerating waveguide? What's a competing design for RF source? What are the advantages and disadvantages of magnetrons versus klystrons? What's your linac using? Have you seen your klystron? How big is it? What does it look like? Why cover it?
- Picture of a patient room (similar to shown below) which room would you put a brachy patient? What brachy treatments require extended stay? Mention LDR Ir and Cs but also I-125 (eye-plaques)...What are your concerns and how would you design a patient room? What are the maximum hourly dose rates acceptable in adjacent rooms? How about corridor? How do you measure dose in adjacent rooms? What if dose is larger than what's acceptable, what do you do? Where do you put shields (show on graph) – why do you put there?
- An illustration of a female pelvis with tandem & ovoid applicator inserted Identify what type of application what are we treating and identify cervix, uterus what's a typical Rx? Where do you prescribe it (draw)? How do you identify cervical os? How do you verify/know that flange is really at os? What's an optimal geometry? What are the critical structures and dose limits? How do you identify rectum point? What's different in Fletcher-suit applicator? What type of sources used in LDR? What's Rx dose and typical dose rate? How long does it take?
- Picture of a CT scanner room what are the differences between CT scanners and CT simulators – can you use any diagnostic scanner in a RT department? How do you do acceptance for a CT simulator. How do you verify spatial accuracy? While talking about couch motion checks, what setup do you use for that? With respect to lasers what kind of lasers are they, how you QA?
- Describe well chambers. How do we use well chambers? Describe calibration procedure for a brachytherapy source What's the frequency of calibration for RAM? Is there a regulation regarding calibration? What does electrometer read? What's a typical value? What would your electrometer read if you drop a PSI seed in a HDR chamber? Any difference between I-125 and Ir-192 calibration. Can you use any source your vendor gives you? Is there any limit on source strength? What do you do if you get a source larger than the limit?
- Picture of an HDR room with nearby rooms labeled as control room, janitorial closet, nearby exam room, corridor, physician's office and modulator room. How do you do



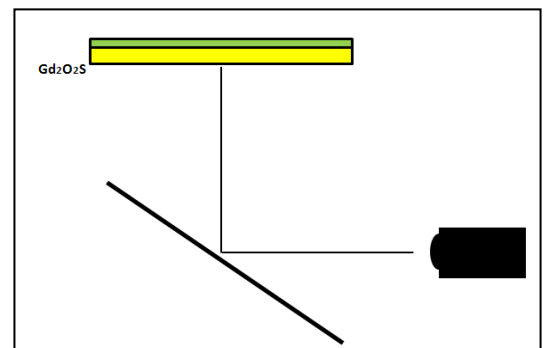
shielding for HDR, write equation. Write down how you calculate workload for HDR What is HVL/TVL thicknesses for Iridium (lead and concrete) What are the corresponding occupational and non-occupational limits. What's defined as controlled and non-controlled areas? What rooms are controlled and what rooms are not. If physicist is the RSO for the department and he wears a badge – would you use controlled area limit for his office? How about a modulator room?

- Picture of whole body PET and CT images. What image modalities are shown? What are typical resolutions in these images? Why do you need PET? What's being imaged in PET? What tracer is used? Describe the overall PET scanning procedure with patient walking in What are the advantages and disadvantages of PET images? How do you do fusion? What ways exists to do fusion? What are typical problems with fusion?
- What's linac acceptance and what's commissioning How do you do acceptance. How to verify the beam quality (i.e. by looking at  $PDD_{10}$ ,  $d_{max}$ , surf-dose etc) ? Why do you want to get a specific beam quality (BJR). How (and with what) do you measure surface dose, what's a typical value for MV beams? What energy machines you worked with? What's  $PDD_{10}$  for those energies (6, 10 and 18)? How do you check isocenter? Mechanical and radiation separately? How do you verify they match? What do you do after you're happy with the machine specs? Who should sign the ATP document? Why do you do commissioning? Can you just get information from vendor?

- With no plots given, asks to draw a PDD curve for electron Show practical range,  $R_{50}$ , therapeutic depth, what gives rise to tail? Where is Brems x-rays generated? What is the spectrum of electron energies out of the linac? Write down equation for mean energy? Write down equation for most-probable energy? What's the energy of the electrons at a depth (write equation) Klein-Nishina curve similar to shown on right What's shown. Explain Compton process What's  $\sigma_{TR}$  and  $\sigma_S$  Explain their relation to energy as shown on curves



- Diagram of a camera-based portal imager shown on right. Point to several parts of the diagram and know what they are? Why use a mirror? Can we just put the camera below the imager? What are the two purposes of metal layer? Can you remove it? What does phosphor do? What material is it made of? What type of EPID do you use in your clinic? What's the resolution? Does that vendor produce a different kind of EPID? What are the differences? What resolution is desirable for EPID? How do you use portal images in clinic? What do you compare to? What's the resolution on DRRs? What are the differences?
- Axial, sagittal and coronal images of brain with isodoses overlaid Is this a linac based stereo-tactic treatment or gamma-knife Do you do SRS? What is important for SRS? What is the prescription isodose line?



- Calibration, survey and use of Ir-192, Cs137, I-125
  - TG 51 dose equation and explain each term and how you use it
  - Pelvis plan (4 field) vs (6 field) advantage and disadvantage
  - DRR for pelvis plan (identify the different structures) and talk about the dose fractionation and the brachy dose levels.
  - Cell survival curve (explain the terms,  $n$ ,  $dq$ ,  $do$ ) talk about RBE and calculate RBE based on two different curves. One is high LET and the other one in low LET
  - Shielding calc with maze. Doses at the maze door and talk about neutron shielding. and the different occupancy factors based on the definition of the rooms
  - Parallel plate chamber and identify the different parts and explain where you would use them
  - Low contrast resolution phantom for CT. how often would you do the test and talk about the different test that you would do for image quality
  - PDD. How does it change with distance, energy and why do we use an acrylic shield for TBI. Lots of follow up questions on PDD.
  - DQE graph vs spatial frequency with 4 different curves (ion chamber, amorphous silicon, and amorphous selenium) explain spatial frequency and how the curve is related to what you use in the clinic.
  - How would you prepare a room to make it into a HOT LAB
  - Explain the dose calculation model for you TPS and explain the difference between Pencil beam, modified batho, ETAR, superposition convolution etc.
  - Isodose curve for a 16mev electron beam with a slopping incidence. Why does the isodose levels not change. Talk about lateral scatter equilibrium.
  - MLC design, explain the design available from the various manufacturers and the different kind of leakage
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- Image of a phantom with inserts of different sizes and contrast. Identify what this test is, how often it is performed and what does the test do
- A treatment room in a facility. Identify the occupancy factor for nearby rooms. What is the ideal location for the gantry head position
- Compton interaction diagram. Easy questions on Compton interaction
- IMRT QA question: ideal dosimeter, film, placement of the dosimeter etc
- 6X 10x10 pdd. Explain different things about the % depth dose.
- Shielding door. Contribution to the door from different components for a low energy and high energy beam
- TG 51 photon beam calibration equation
- prostate 4 field vs imrt plan
- Different mlc designs by the vendors. why rounded leaves, transmission through the leaves vs blocks
- Graph of electron density vs. HU. Describe the graph. What is the ed of air, water, lung and bone. What's the difference between drr and a radiograph.
- Design of a parallel plane chamber. Identify different components
- Difference between image fusion and registration? Intensity based and mutual information based registration.
- Emergency procedure for an HDR accident
- What TPS you have. How does the beam modeling work
- gantry star shot film

- Question on radiobiology- a cell survival curve. Questions on it.
  - Electron beam incident obliquity. Why are the isodoses parallel to the surface profiles at different depths. Flatness and symmetry, how often
  - Diode chamber. Identify the parts and various questions
  - Different organs drawn on a female pelvis radiograph. Identify the structures
  - Radiation safety precaution for the hotlab in a new facility
  - LDR implant..what is the procedure, what is differential loading instrumentation, procedure for calibration of ir-192, I-125 and cs-137
  - DQE vs spatial frequency
  - Waveguide question:
  - Image of an electron beam at about 40 degree angle from the surface: There was a hot spot on the side where the SSD was less also, but the lower isodose lines (20 and 30 percent) were parallel to the surface. Question: Why are the isodose lines parallel to the surface?
  - Look at the PDDs at different SSDs in Kahn.
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- Graph of DQE vs. Spatial Frequency with three lines labeled: video, aSi, aSe. Question: Describe the graph in detail. What Detector Quantum Efficiency stands for, and what the graph relates for what is stated to be 3 types of flat panel detectors for portal imaging.
  - Emergency procedures for HDR if the source stays out. How would you know that it is still out? How to check the calibration on Ir-192, I-125, and Cs-137 LDR sources.
  - Listing of the different algorithms that have been developed and talk about each one and what you have in your system.
  - Look at the task group report on inhomogeneities.
  - Image of a low contrast resolution CT phantom that is very grainy in the image. Question: What is this, how was it produced, how is the CT# vs Electron density graph different for a CT unit and our Tomo unit, definition of CT#, what could be done to improve the quality of the image, how would you know if it is acceptable. Explain door shielding for a vault with different energies and different door types (with and without a maze).
  - Image of a vault with a secretary on the room to the left, and in the rooms to the right, a hallway below, and nothing on the upper wall. Which way should the machine be installed and why?
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- Picture of a vault and surrounding workspace, hallways, and a class room. Discuss use factor, occupancy factor, dose limits. How would you place the linac in vault?
- A 4 window view of an IMRT qa from TPS. What is it? How do you pick a point? How do you measure if good or bad qa? the equation for gamma.
- Picture of Compton scattering. What is it? Angles for max/min electron energy. What clinical settings is this important in?

- A diagram of p-type diode from Khan.  
What is it? Describe operation. Direction of current flow. Why is there bias voltage in the picture? How much bias voltage applied (he was messing with me at this point)?
- A graph labeled "DQE". This means Detector Quantum efficiency. Know to discuss it in very generic and brief terms.
- A very odd diagram of a klystron. What is it? How is RF generated? What effect does changing the distance between cavities have?
- A side-by-side comparison of 4-field and 6-field male pelvis plans from TPS.  
What are these? What are advantages of one over other? Discuss nodes. What would be the difference with an IMRT plan? Tolerance doses.
- A DRR of female pelvis, AP view. What is this? What would be treated with this field? Be sure to discuss nodes and blocking. Locate the bladder and rectum. What is typical script? Would brachy be involved at some point?
- How do you cal different brachy sources, i.e. Ir, Cs, I?  
Just wanted me to walk him through the entire process. What type of instrument, how cal, who cals, etc? Pretty general terms.
- What to do in the case of HDR emergency?  
Wanted to know about actions taken outside the room, i.e. pushing stop and emergency stop buttons. What do you do inside? Who provides training for staff? Why do you train the staff? Basic stuff.
- Picture of an L-shield. How would you set up a hot lab? How do you control access, how do you account for sources, what instrumentation, etc?
- The photon equation from TG51. Describe each term. If you do this in detail then there is no time for follow up questions.
- Photos of CT resolution test. What is this? Why is it important? How does the CT image affect TPS? How often is it done? What other tests done on CT?
- Why is CT the standard for radiation therapy planning? Discuss pro's and con's of CT, MRI, PET, SPECT.
- A list of dose algorithms. (standard list of 5 or 6)  
Discuss what your TPS uses. Discuss each of these. Adv/disadv of each. What does your TPS use for fusion?
- A graph of dose profiles. These were taken at near surface, 10 cm, and greater than 10 cm. Discuss shape of each. Discuss limits for flat/sym. Detail the equation and methodology for determining flat/sym.
- A 2D contour of 15x15 electron cone at a 30 degree angle to flat, homogenous phantom. Why are the distal contours parallel to phantom surface? Is that what you expect? Why?
- A diagram of a very basic square shape with an area for a door, which is supposed to be a vault. Discuss door design. Discuss neutrons. Discuss vents/ducting at door. Discuss gaps at door. Very basic.
- A very poor diagram of parallel plate chamber. He actually apologized for the diagram. What is it? Basics of operation. Why you would use it? Makes and models used in clinic.
- A graph of depth dose. What is this? How does it change with field size and SSD?
- A picture of MLC. Discuss the different types of MLC, i.e. sizes, focus options. Discuss dosimetric properties of MLCs for beam modeling.
- Another question about why we use CT and not other modalities. Same as before.

- How would you go about planning a brachy sarcoma case? Walk through from start to finish. Some guidance given.
- A cell survival curve, 2 different curves on same plot. What is it? What is  $D(0)$ , surviving fraction, quasi-threshold? Which is high LET?

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- How does your clinic's TPS work? How does it correct for inhomogeneity? Explain convolution-superposition and how correction would work.
- Picture of a star shot film. What is this for? tolerances of rad and mechanical iso. Led to differences in tolerances for radiosurgery.
- What is an HDR emergency? What would you do in that situation? How to find seeds lost on the way to an implant – scintillation counter.
- Picture of a treatment room with secretary offices on either side, a maze hallways on the other sides and a control area. What the limits are for those areas for occupational workers and the public. Where would you put the linac in the room?
- Image fusion. How does mutual information work? Seemed to want the mathematical relationships. What are other methods and how do they work? Is there a difference between multi-modality and same modality fusion?
- Electron beam is incident on a surface at a 30 degree angle. Shown isodose lines. Why are isodose lines ~parallel to surface?
- Cell survival curves shown. What are  $D_q$ ,  $D_0$ , and  $n$ ?
- Ir-192 ribbons questions. QA of HDR, planning QA, and source QA.
- How do you design a Cs safe? about a hot lab or other storage facility for the safe. Signage for hot lab and other safety concerns.
- How do you calibrate Ir-192, I-125, and Cs-137? Led to wipe tests – how it's done and with what frequency. Also discuss about well chamber calibration – how it's done and with what frequency.
- Draw EPID and describe the components. Differences between direct and indirect. What is the resolution of an EPID image?
- Describe the accelerating structure of the linac – traveling wave and standing wave. This lead to a follow-up about how a magnetron worked.
- Shown IMRT plan calculated on a phantom. Talked about IMRT QA. How you do it at your clinic, what are some of the issues of fog in a H&D curve film.
- Shown 6X PDD. What happens at surface for larger field size? What is the build up region? What happens at surface at 110 SSD?
- What are the differences between diagnostic and therapy CT?
- Shown a picture of Compton interaction. Explain what it is, at what incident angle is the most energy transferred to the electron and at what incident angle the electron has the least energy.
- Shown a picture of a door and had me draw the cross-section of a door without a maze for a high energy linac room. Talk about what materials (lead, borated-polyethelene) and why and what order they should be in and why.
- Picture of an MLC. Talk about different manufacture's designs and the pluses and minuses to those designs.
- What is CT the standard imaging set for RT? What might you want other types of imaging as well?



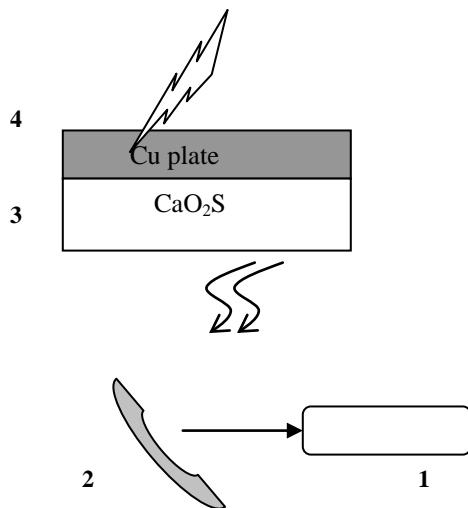
- Shown 3 views of conformal prostate plan and a 4-field box. Explain about critical structures and advantages and disadvantages of each plan.
  - Shown the TG-51 equation:  $D_w = MkqN_{DW}^{60}$  What is  $kq$ ? How do you get it for electrons and photons? What is  $kq$  for Co-60?
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- TG51. Shown equations for photons and electrons. Explain each factor. What is the beam quality? How do you find  $kQ$ ? Why do you need the lead foil? What correction factors do you need?
- 2 prostate plans (four field and six field). Point to prostate, seminal vesicles, bladder, prostate, femoral heads. What dose do you use? Do you boost? Which plan is better and why?
- Describe MLCs for different vendors. What are the advantages/ disadvantages for each?
- Picture of a linac vault door. What materials do you use and why? How is it different for high vs low energy machines?
- Picture of a parallel plate chamber, know how to draw one. Describe each of the parts. When are they used and why? What is the size of the spacing? What is a well guarded chamber? Is a markus chamber well guarded?
- Picture of HDR. What type of detector do you need? How does a GM meter work? Compare scintillator vs GM meter.
- TPS algorithms. Describe TERMA and kernel. Where does each come from? How does your planning system handle heterogeneity? What are other ways?
- Picture of image fusion. When do you use fusion and why? What types of images? Describe the algorithm used.
- Image of female pelvis. Point to bladder, rectum, and iliac nodes. What structure are you treating? How do you treat it? Describe point A, point B, etc. What dose/fractionation do you use?
- Diagram of a diode. How does it work? Do you apply a bias? What happens if you apply a bias?
- Image of 3 profiles at different depths. What is this? Define flatness and symmetry. What are the tolerances? What do you think the depth is for each curve? Why does the flatness change with depth?
- Cell survival curve. Explain factors in the multi target theory. What does each represent physically?
- Electron beam incident at an oblique angle. Why are the isodose lines parallel to the skin surface?
- EPID. Draw a diagram of an EPID and explain its parts. How is this different from OBI detector?
- Picture of a linac accelerator structure, Explain how electrons are accelerated. Compare a magnetron vs klystron.
- Cs hot lab. How would you design the shielding? What if it's not enough? What else do you have to consider besides shielding? Frequency of leak test? Inventory?
- Calibration for I, Ir, Cs. Describe well chamber. How do you verify activity of your sources? What is the tolerance? What would you do if the difference is more than that?

- Picture of HDR. What do you do if the source is not retracted into the safe? How do you calculate the dose/time? What do you do for a second check? What about a second check for a planar implant?
  - Picture of linac room. How do you shield? Where do you find guidelines? Explain W, U, T, P. What numbers would you use for each?
  - Image of CT phantom. Describe contrast resolution test. What is tolerance? Why do you do it?
  - Picture of dose buildup curve. Explain KERMA, dose buildup region.
  - Picture of Compton scatter. What is going on here? What angle gives max and min energy to the electron? Explain why this is important in therapeutic imaging.
  - IMRT plan. What do you do for QA? What chamber do you use? What type of film? What is the accuracy of each? Where would you put the chamber to do a point measurement (point to on plan)?
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- Shown a diagram of a magnetron and a klystron. Describe them and how they work. Follow up on how they're different and what are the advantages and disadvantages of each.
- Shown a PDD curve of a high-energy electron. Know how to explain; what causes the shape of the curve in the buildup region.
- Polarity effect. What causes it? How does it change with energy? Is it different between cylindrical and plane parallel chambers?
- Two axial slices of a four -field box prostate treatment. One is low energy, one is high. Explain the differences. How could you improve target coverage? What are some alternative beam arrangements/ methods?
- Shown an empty treatment vault with a maze. Where would you place a linac? Discuss the shielding considerations.
- Shown an electron PDD. How does it change with energy?
- Discuss the differences between standing wave and traveling wave accelerating waveguides.
- Shown a diagram of a 90 degree bending magnet with beams coming in straight on, at an angle, and at different angles. Explain why they are deflected onto a target differently. Discuss other types of bending magnets.
- Beyond what energy do neutrons pose a shielding issue? What are the sources of neutrons? How do you shield for neutrons? How are the neutrons produced? What is the equation? How are they measured? What is the equation? What methods? Explain the functioning of instruments used in measuring neutron doses.
- Identify  $R_{50}$ ,  $R_p$ , most probable energy  $E_p$  and energy at depth  $E_z$  for an e-beam. What are the rules of thumb for the practical range of electrons? What are the rules of thumb for electron dosimetry?
- Shown the Fig.1 graph in TG-51. Explain the graph? How do you convert depth ionization to depth dose? For e- and for photon beams? What are the correction factors involved?
- A graph of Compton interaction cross-sections shown? Identify the various curves Energy on x-axis, Compton Interaction X-section on y and three curves drawn as  $\sigma_{tr}$ ,  $\sigma_a$  and  $\sigma$ . What does each curve indicate?

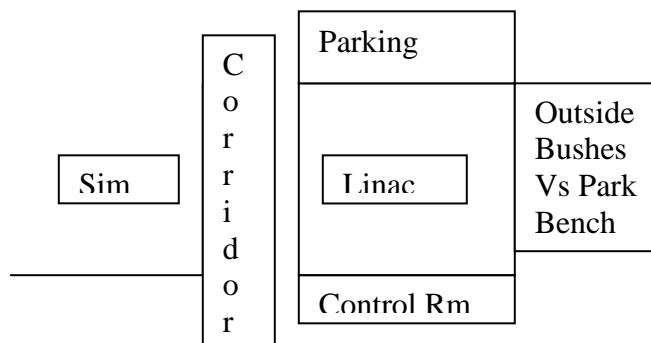
- Shown a picture of a diagnostic x-ray tube. Identify various parts? What are the electronics associated with the x-ray production? What are apparent and effective focal spots? Typical target angles? Why is focal spot size so important?
- Shown a picture of a CT scanner? Identify various parts. What is the distance between internal and external laser intersections? What are the QC tests you would do on a simulator QC? Sometimes you have to do CT scan in an orientation that is different from the treatment geometry? How do you go about transferring the data correctly?
- Shown a picture of GAFchromic film response. What is it made of? How does it compare with the response and function of a film? What is it used for? What are the advantages and disadvantages?
- Schematic depicting various parts in a TLD readout system. Explain the function. What are the wavelengths? Any filters – which one and why? How is the signal amplified in PMT? Explain the electronics in a PMT.
- Two MR brain axial images are shown? Not the same anatomy. Explain various structures? T1 or T2? What MR images are typically transferred into TPS? Explain the workings of contrast mechanisms in MRI? [Typical field strengths in an MRI? Smallest field strength used in imaging?]
- Shown a nuclear medicine scan – looked like a full body PET study? What is this? How and where is it used? What are typical doses to patient? Safety issues related to PET patients?
- Two images – one CT and one MR were shown. Which is which? How does fusion work? What are various ways of doing it?
- An accelerating waveguide - Identify various parts and their function. (vertical orientation, with buncher and catcher cavities, heated cathode)
- Brachy – Calibration of LDR sources? Does it need to be calibrated or checked, activity-wise each time?
- Brachy – Three adjacent rooms with beds. Which room to use and why? Give typical exposures and limits.
- Brachy – shielding for a HDR unit and room? Typical HVL/TVL values.
- Brachy – Picture of a tandem and ovoid are shown. Explain the picture? Where is the rectum point and where is bladder point? What are typical source loadings? Shielding in the ovoids? Tandem?
- Brachy – one I-125 seed flushed out in toilet. What would you do? 20 I-125 seeds (0.5 mCi each) on the way to land-fill. What would you do? Instrumentation – why?
- What is acceptance testing and what is commissioning? Define clearly and explain what you would do in each case. How do you check the accuracy of the mechanical pointer (if it fell down, etc). How do you get TMR tables calculated/measured and input them in TPS? How are  $S_{cp}$  factors measured?  $S_c$ ? How would you measure  $S_p$ ? How do you check the isocenter rotation? Explain how you would do \* shot, etc.
- Stereotactic surgery. Three views with isodose distribution were shown. How was this treatment plan produced? Explain what are the other means of doing stereotactic surgery? Told mini MLC based. Could have said Cyberknife as well.
- Schematic of EPID. What is this? What are the things labeled as 1, 2, 3 and 4. What is the function of each? Can you get an image without copper plate?



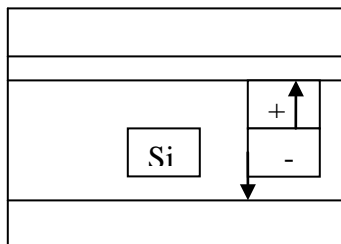
- What are stochastic and non-stochastic effects? Explain. Provide clear examples for both these effects.
- Three plans with two abutting fields were shown. Can you identify the energies of the two fields? Explain the three plans. Which is better?
- What is a double focused MLC? Explain the functioning of it.
- Draw a schematic of an ionization chamber. Various parts and function. What are typical values for diameter and volume of an ion chamber.
- What are the units for air kerma strength? How is it calculated? Units?
- What is a Sievert integral? How is it calculated?
- Shown TG-51 photon equation. Explain parameters.
- Calibration and QA differences of I-125, Ir-192 and Cs-137 sources.
- 16e beam entering surface at a  $30^\circ$  angle. Explain why the isodose lines look like they do.
- How do you set up a hotlab?
- Picture of a door for an 18 MV room. Explain shielding concerns for door and HVAC entering above the door.
- Picture of a linac vault and surrounding areas. What are the occupancy factors, permissible dose limits, best linac orientation?
- Picture of an MLC. Talk about MLCs. Different types, penumbra, transmission, etc..
- Plot of DQE for video based, aSe and aSi portal imagers. What is this? What is resolution (lp/m)? What does this mean? Which system is better?
- What is an ion chamber? What is it made of? Why? Why cylindrical? Volume of, etc.?
- Very crude parallel plate chamber diagram. What is this? What is it used for? Is it vented? Where/how?
- Picture of four squares with circle cutouts in the center (to represent traveling waveguide) separated by distances L1, L2, L3 with a plot of a sine wave below. The negative portion of the sine wave was shaded. What is this? Are L1, L2, L3 distances the same? What happens during the shaded portion of the wave?
- Picture of IMRT QA phantom with isodoses from the tps. What is this? Where would you place chamber? Why? Can you use other method with this phantom? (Had places for film.) What is pass/fail criteria? Why? What do you use at your institution?

- Picture of a spoke shot. What is this? What is it for? How do you place film? Which on is this (gantry, collimator, table)? How can you tell? What is the pass/fail criteria?
  - Photon PDD curve. What is it? Why is surface dose low? What would happen if increase energy? Increase field size? Increase SSD? Why?
  - Image of a contrast resolution phantom. What is this? What is it for? How often do you use it? What are you looking for? What if it fails? Any guidance document?
  - Picture of an HDR treatment to neck area. How do you enter the room? How do you know source has retracted? What do you do if it hasn't? Explain about medical event. Who gets notified?
  - What treatment planning system do you use? Explain how it works. Explain how heterogeneity corrections are done. Had listed on the screen Batho Power Law, ETAR method, Differential Scatter-Air Ratio, Convolution and Monte Carlo.
  - How to get electron density information from CT to TPS. Hounsfield units, write equation for conversion of them, how do you measure, etc.?
  - When would you use a diode for beam measurements? Why? What are the advantages and disadvantages?
  - Axial, coronal and sagittal views for two different plans (4 field and 6 field). What are these? What are the differences? What are the advantages? Compare dose to critical structures. Which one is better?
  - MRI and CT slice of brain at different levels. Can you fuse these two images? Various follow up questions on advantages/disadvantages of image fusion. How do you do it (talk about the different methods)?
  - DRR with structure contours from tps. What is this? Where is the bladder? Rectum? Iliac nodes? What are the critical structures? Dose limits?
  - Shown a diagram of a diode. Various parts labeled. What is this? Arrows pointing in different directions, what happens here? How does it work? Is it dependent on temp., energy, voltage? Why do you use it?
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- What tests do you do for annual QA on Linac, explain in detail setup & parameters.
- Nuclear Energy Well diagram from Khan book: What keeps the nucleons together?
- Picture of Prostate DRR sagittal view: Identify contours/organs? Define what is GTV, CTV, PTV, TV and ITV where does ITV fit in the sequence. What ICRU report defines these terms? What are OAR and PRV and their max doses in this case? Why we create PRV from OAR contours?
- Layout of Linac Room shown below: Calculate workload for shielding this facility? Define Workload? What effect does IMRT have on Workload?



- Write all Shielding equations for facility layout shown above,  $B_p$ ,  $B_s$ , &  $B_l$  (primary, secondary & leakage). Explain all terms in the equations. What NCRP report would you follow? What permissible doses would you use and why? Where do these numbers come from, what report?
- Picture of DRR & EPID snapshot: What are we treating here? What is the purpose of the gold seeds in the prostate? How do you localize prostate for daily treatment.
- Picture of Linac head shown with parts – waveguide, bending magnet, flattening filter, scattering foil, monitor chambers, jaws & MLCs. What annual test checks the proper functioning of each of these parts? What is your favorite test from the annual calibration & explain how do you do it & what are the limits? (Star Pattern Shot Test) How do you verify radiation isocenter is coincident with the mechanical isocenter? How do you check radiation & mechanical isocenter?
- Picture of a Phantom shown along with a picture of different size holes from bigger to smaller. What is this and how often do you perform this test? What tests do you perform for your monthly CT QA? What report to follow?
- Picture of electron beam isodose curves: What are we looking at? Can you guess what energy beam this is and how do you know? Why do electrons scatter more laterally?
- Picture of Gyn Applicators: What are these? What types of cancer do we treat with these? explain Henschke procedure, the way we do it at your facility, explaining the insertion of the applicator, the planning procedure stepwise, Rx doses and dose limiting structure doses, the second check procedure & equipment QA before the treatment. What else besides HDR can this equipment be used for?
- Ct & MRI images shown: What are these images? What modality? How do you know? What are the characteristics of these images? Why do we do fusion? What are the advantages and limitations of fusion?
- In the picture of EPID layers Identify all layers & describe its function? How does EPID work? What is Si layer for? What is the composition of the layers of the EPID?



- Picture of a detector shown: Identify the detector? (Diode) How does it work? What is it used for? And Why? What are the advantages and disadvantages?
  - What is the difference between ion chamber used for monthly & annual calibration and why? Why use a small ion chamber?
  - IMRT QA: How do you do it and what are the tolerances?
  - Varian & Siemens MLC: differences and similarities? What does dual focused means? Why does Varian have rounded edge MLC?
  - Do you ever adjust your machine output after monthly? Why? How do you justify it? If output is different by 1.7%, what would you do?
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- Pictures of three axial isodose distributions. They were photon/electron field abutments with different gaps. First one had typical hot spot on the photon side; the other two had increasing gap widths with cold spots. which one is best, and what you could do to make it better.
- Diagram of farmer chamber. Name the parts and what they are made of. Typical size?
- Diagram of parts of a portal imager. Name the parts and what the device is used for. What is the Cu layer for?
- Picture of basic x-ray tube. What type of electronics/circuits are used (supposed to say step-up transformer and voltage rectifier). Question about the angle of the anode. Questions about neutron production in an x-ray vault. What is the cutoff energy? What is the reaction? How do you detect neutrons outside the accelerator?
- Diagram of three rooms and question about LDR implant. What is dose limit to member of the public? What to do if you determine patient in next room is getting more than limit?
- Diagram of cancer center with HDR vault, offices, etc. What are the occupancy factors for the different areas? How to calculate workload for and HDR?
- Picture of electron PDD from TG-51? Why do we need to know  $kr_{50}$ ? Why do we shift the curve. What direction do we shift the curve? He then had me draw a 6 MeV electron PDD.
- Two MRI images; one T1 and one T2. Point out the structures ethmoid sinus, lens, optic chiasm, optic nerves. How can you tell the difference between T1 and T2? Why would we need to see T2?
- Cartoon of T&O inserted in patient. What is the difference between what you see in picture and Fletcher-suite applicator? How would you reduce dose to rectum?
- What to do if patient flushes a seed down the toilet? What if 10 seeds are lost in trash?
- Diagram of a multicavity klystron. What is this and how does it work?
- Picture of PET and CT and PET/CT. Questions about fusion and what the PET is used for. How does the PET work?
- Plot of OD vs. dose (H&D curve) for gafchromic film for different energies. What is it used for? Is there any energy dependence?
- What are stochastic and deterministic effects? Give examples of each.

- TLD question: reference Kahn p145 How does TLD work? What is the material? Do you use TLD or diode. What is the advantage of TLD over diode? Glow curve and annealing. Know heating temperature, the use of optical filter, function of PMT.
- CT image quality phantom. One slice of image showing low contrast resolution test. Several rod with different diameter. What is this test for? Why is it important? What else do you do for your CT QA?
- Question on either VW or EDW (depending what you use). How does it work? What is STT table? How many angles does it have? Do you verify your STT table?
- Picture showing several cavities w/ first several cavities being non-equal spaced and later ones equal spaced. What is this? Are the cavities equally spaced? Why? In the later cavities, electrons are not gaining speed, are they still gaining energy? How?
- Farmer chamber and parallel plate chamber What are they? Dimensions? Details about construction/material... Do they require shift? How much?

- There are 4 other questions regarding different parts of LINAC. You have to be familiar with pretty much everything. From Klystron/magnetron/accelerating waveguide/electron guns/modulator/bending magnet/x-ray target/filter/monitor chamber/scattering foil/X Y jaws/MLC, etc...
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- How do you do QA for brachy sources ? What is the instrumentation you use? How do you measure source strength. If you do not have LDR brachy sources, explain the HDR process. Could you calibrate the sources with a Farmer chamber.
- Picture of EPID. Shown was a figure of EPID with a Cu plate and a GDSO4 plate beneath it. Show an incident beam and one photon which went through it and one electron which scattered and that was reflected in the mirror and detected by a camera.
- Picture of Klystron with lot of labels on it. Primarily described the klystron, said that it was a MW amplifier. Know what the source is and that it required a low MW oscillator source. Where is the source of electrons,
- HDR tandem and ovoid picture. What is this and describe this. What is the difference between Fletcher suit and this. Discuss.
- Radiation shielding Q. If one seed gets flushed in the toilet what would you do and if 20 0.5 mCi seeds get lost in hospital trash what would you do.
- Shown a picture of CT scanner. Discuss. What is this? what are the QA associated with it? How do you QA for lasers. How to do a QA for sending images to the TPS.
- Diagnostic picture of a rotating anode and some sub questions on them.
- Attix Graph of Total Compton cross section, transmission Compton  $C > S$  and scattered Compton  $C > S$  with energy. Know how to identify the different areas and explain.
- Diagram of SRS plan with oval isodose lines on it. The questions were what are the two different types of SRS. Compare cone sizes. Difference and advantages if any between cone based SRS and MLC based SRS. What are the limitations, if any, why is there a limitation.
- TLD reader Diagram. Explain the process. Sub question about PMT. Why is HV needed at the top What does the amplifier do.
- shown T1/T2 MRI, explain the differences.
- On CT/ MRU identify which one is which. what are the different structures,
- TG51 Electron PDD/ionization curve. Explain what is this. How do you convert it to a depth dose curve.
- Question on Neutron Shielding. Above what energies do you worry about the neutrons? How do you shield a door for neutrons. How do you measure neutrons. above 10 MV one should worry about neutrons, shielding should be for energies 15MV and above. Draw the diagram of swinging door and composition and a pocket door with its composition. Know that inside the room we measure the neutrons with activation foil. Give the formula. Outside the room we use Rem ball counter and gave the Boron formula.
- Picture of a thimble chamber. Know to identify parts. Such as the central electrode and the possible materials, the outer electrode and the guard. Know the chamber of volume. Which parts of a triax cable would go to which parts of the chamber.
- Isocentric MU equation. Explain each term. How would you measure SC and SP. Further sub questions on sc measurement followed with use of build up cap while measuring the sc factors. Know different build ups one would use.



- PET CT images. Identify these. Difference between registration and fusion. Correctly answered all questions and sub questions. Fumbled a bit with registration but gave eclipse example of the registration process.
- Shown a HDR vault. Many questions on this. Know how to calculate taking some random numbers for workload.
- Commissioning and acceptance. Difference. Steps of commissioning. Answer this question in depth and gave all the steps and necessary answers to the sub questions.
- Electron Questions. Ep, Ez, Rp. E0. Give all the formulas and write them down.
- Question on stochastic and non stochastic effects. Definitions, examples, dose limits etc. Know the limits for lens, cord, kidney.
- Radiochromic Film graph. what is it made up of. Such as base with polymer coating How Is it processed. Know that it does not require any processing as conventional films. question about the graph. Which energy range is it most effective. Know the definition of OD and Write it down. Questions on scanner calibration.
- Question on Fusion – Different kinds of fusion.
- Machine commissioning questions. How to survey neutron measurements. How would you measure for scatter and leakage (survey meter for scatter with phantom placed on the table and films wrapped around the head for the leakage measurement).
- Describe of characteristics of broad beam vs. narrow beam? How does the HVL graph between them differ? Which should be used for linac shielding? In diagnostic filter measurements?
- Two images a DRR and a portal image of a lung/Mediastinum Tx. Which one is DRR and which one is portal? How do we obtain each image and which one is the reference? Which image is better (quality wise) and why? Is there an anatomical site in both images that you can reference to see if they are matched or not. If not matched, what do you do? Shift patient to left or right. ?

- Sagittal image of a treatment planning screen shot of subjects contours (bladder, rectum, prostate, Seminal vesicles, nodes).

-What is this image?

-Define each subject contour?

-Why there was a break between rectum contour and nodes contour

-Where is the PTV for both primary and boost? (prostate +SV for primary, Prostate only for boost)

-How do you treat this and what dose do you prescribe?

- TG51 Electron beam calibration equation

$$D_w^Q = MP_{\frac{Q}{x}}^Q k'_{R_{50}} k_{ecal} N_{D,w}^{60Co}$$

- What is this equation?

- Define  $k'_{R_{50}}$

- What is the depth correction

- How do you obtain it?

- The follow up question was about why do we use CO-60 beam for calibration? Why not a linac. Know that we cannot use a linac because the linac output is not constant and needs to be calibrated too. The CO-60 beam has two constant energies, but

mainly because the exposure rate constant is a constant value and dose not change with activity.

- Two MU calculation equations one for SSD and one for SAD setup. Define these two equations? What is  $S_c$  ? Where does the scatter come from? How do you measure it? How is the setup, depth, SSD, etc.? Why do you use the buildup cap? What is  $r_c$  ? What is  $S_p$ ? how is the set up, depth? What is  $r_p$  ?
- What device would you take to an I-125 implant? What if an Ir-192 implant?
  - What instructions do you give the patient upon leaving the hospital
  - What are the releasing criteria for I-125 prostate seed implant patient. He was looking for a measurement type data that a physicist has to do before he/she can release the patient.
- Two sets of brain axial images; one MRI and the other looks like PET (very poor quality images)
  - Define these sets of images (what modality)
  - Explain how image registration (fusion) works? What other methods of fusion?
- Explain where the ion chambers are inside of LINAC. How do they work and how to commission them? What kind of data do you take?
  - What kind of chambers are they?
  - Know what kind of accelerator you work with and then Know how to draw a cross section of the chamber and what each sector represents
  - How do these chambers measure flatness and symmetry?
  - In electron beam, what depth do you take your profile at?
  - In photon beam, what depth do you take your profile at?
- Why do we survey and check interlocks for a new LINAC first? What steps do you do for acceptance of a new LINAC? - Do you survey and then check the door? Do you check door interlock first and why?
  - What kind of survey do you conduct?
  - What other tests do you do (they are in three parts: safety, mechanical, radiation)
  - How do you check for collimator rotation (mechanically)?
- Film dosimetry
  - a H&D graph is showing, define the terms
  - OD vs dose, what kind of films do you use at work
  - what is fog? What does fog include (noise, ..)
  - What is net Optical density
  - Where do you use the film in the clinic, monthly machine QA, electron PDD, etc.?
  - Do you use VX film in IMRT QA? Why not? What other film do you use for IMRT QA?
  - What are the disadvantages of using film?
  - Explain how you obtain calibration curve for film dosimetry?
- A series of axial CT images with a lung/Mediastinum PTV contour on them. This looks like CT images during respiratory gating.
  - What are these images for?

- Explain IGRT? Why can't we expand the margins?
- A cartoon picture of patient in a CT/sim room with IGRT procedure
- Define each part (marker, infrared camera, goggles, respiratory cycle on a monitor)
- Explain phase gating
- How do we scan the patient? How much data are we getting? Are all these images sent to the treatment planning computer? Know about patient dose during this type of scan?
- Radiation Protection
  - Define with equation mean dose equivalent
  - Define with equation effective dose equivalent
  - What is the weighting factor for gonads?
- Shown the electron beam incident on the slab bone heterogeneity from Khan. What effects will a lead sheet on a patient skin have on the electron isodose curves?
- Explain the release instruction of prostate implant patients.
- Know about discharge instructions for an I-125 prostate seed patient with a pregnant wife. What are limitations for time spent with wife or small children? (Be specific- how long do limitations, if any, need to be in place?) What if patient finds a seed in the toilet?
- Dose calculation for I-125 prostate seed implant given the initial dose rate ( $D_0$ ).
- Know about dose imitations for workers and pregnant worker in specific
- HDR daily QA. How to do it and what is used. What should be done before patient treatment (mechanical, patient specific, and radiation protection)
- Shown an HDR Tandem and Ovoid. Know to identify bladder, how much contrast should be in bladder? Know to identify the function of the "metal blade" shown on the orthogs. Looked like a rectal shield. Wanted to know what acceptable doses to the bladder and rectum were. Define (according to ICRU) Point A, B, Rectal point and where its location on the lateral film, bladder point and its location on both the AP and lateral film.
- CT/Sim picture. Define each part. What does the simulator software do? What kind of tests do you do during acceptance testing? What are the limits for (i) lasers, (ii) anatomical data, (iii) DRR
- Shown a graph of KERMA vs dose. What are we looking at? Describe what is happening in this graph? Where does the electronic equilibrium take place? Show on the graph? Why is the KERMA part under the absorbed dose curve after  $d_{max}$ ?
- 3- IMRT optimization - Explain algorithm. How can we avoid more than one local minima? Why can't we have the same planned vs. measured IMRT plan (MLC speed difference,  $QA \pm 3\%$ )?
- Transverse abdominal CT Image artifacts with contrast agent in the abdomen. Know what is happening? Why do we get streaks of white lines? Write down HU equation and define each term. How do you obtain CT images? Explain (filtered backprojection algorithm). What is the interaction that causes this artifacts? (photoelectric absorption)

- A cross section image of a Magnetron; describe its components, how does it work? Where do you think the direction of the magnetic field is? What kind of power output in MW? What about the power output of Klystron in MW?

END