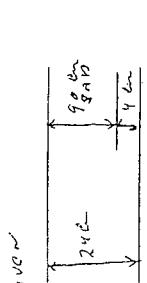


1. Several questions concerning the NRC regulations. (see below)

2. Calc. dose to cord



3. Many questions in TG 41.
4. Some TG 30 questions. \rightarrow ~~TG 41~~
5. also TG?? On electrons.

6. Dose to patient on Linac $\times 3$ } Needed to interpret charts, Inv sq.

7. Dose to patient on Co. } Eq. Sq. Calc. etc.

8. All data was given when isotopes were involved i.e. T1/2, HVL, f factor etc.

9. TMR calculations

10. Given dose to an isodose line i.e. 200 cGy to the 105 % isodose line what is given dose for 100% to field #1?

11. Follow up to above lat field had a wedge and asked to calc given attenuation of wedge and asked to calc given dose use data from above.

12. F factor calc. given $\frac{1}{\sqrt{2}}$ H₂O and muscle etc.

13. Thickness of A₁ needed to compensate for missing tissue. Factors given. \rightarrow

14. Se and Sp calc. given TMR. Collimator open 40x40 blocked to 8x8. Calc. Mu for midline dose.

(15) Neutron questions width of maze effect on scatter energy at end if maze. T-F A wider maze will give less scatter at the door than a thinner maze.

(16) Given a 20 MeV neutrons and the door mounted backwards i.e. Borated poly on outside, what is the energy of the gamma coming off poly? Given choice of answers 10 KeV neutrons, 10 KeV photons, .5 MeV photons, 100 KeV photons and 10 MeV photons.

17. questions on acceptance checks for wedge factor. See below determine neutron dose from which selection of beams.

a. Both 6 and 18 photon

b. 18 photon and all electrons

c. 18 photon and 20 electrons

d. 18 photon only

19. Gap calc.

20. Manard's f calculations.

21. Many brachy question all factors given and T1/2 etc.

22. Calc dose from Ir after 45 days. Given Do= 8cGy hr T1/2 must convert days to hours etc.

23. Could not remember any HDR or stereo questions.

24. Many WF questions. Ie wedges from fields 90° and 220° and 180° apart, in plane cross plane diff FS, depth doses, dynamic wedge.

25. Dose outside of Rm need for additional shielding or if it meets NCRP standards. T1/4, U1/4, and W, given instantaneous dose rate. Reduce to 2 mr/hr (similar to questions on previous exam).

$$\text{Rate}_{\text{outside}} = 0.5 \text{ rad} \cdot \text{min}^{-1}$$

26. What is allowable dose to frequently exposed member of public? \checkmark ~~0.5 rad~~

27. Dose at 2 cm depth on field prescribed to 6 cm depth with cobalt 60 and 9 MeV electron, electron %DD curve given. 5Gy electron and 40 Gy at 6 cm depth with cobalt 60 no cobalt 60 data given.

28. Target angle of therapy x-ray unit greater than diagnostic unit. (T-F) \checkmark

29. Target of therapy x-ray unit not transmission type (T-F). \checkmark

30. Skin dose from superficial unit greater than electron. (T-F)

31. Many simulator questions, can't remember exact questions.

32. Some radio biology questions.

33. The NRC requires a wipe test on linac collimators made of depleted uranium. (T-F) \checkmark \rightarrow ~~deplete~~

34. You can drill/screw into a depleted uranium collimator? (T-F) \checkmark \rightarrow ~~remove~~ ~~airbone~~ ~~porosity~~

35. Linac jaw are made from natural uranium? (T-F) \checkmark

36. Natural uranium is commonly used as raw material for linacs. (T-F) \checkmark \rightarrow ~~deplete~~ ~~uranium~~ ~~contamin~~

37. What provides the greatest contribution to the dose from I-125 implant.

- a. gamma rays

- b. fluorescent photons

- c. auger electrons

- d. beta rays

- e. internal conversion electrons

38. When commissioning a set of new wedges, which of the following must be measured?

- a. wedge factor vs. Depth

- b. wedge factor vs. Field size \checkmark

- c. wedge factor vs. Off access

- d. wedge factor for the average chamber reading with gantry at 0 and 180 degrees.

Can not attest to exact format on wording of questions but the idea of what they were looking for is stated. I felt it was a fair test and had many appropriate questions asked. I finished with $\frac{1}{2}$ hour to spare. One unique screw up on exam. 2 of the 15 point questions had the correct answer marked in the text booklet, they were marked with a *.

Good Luck

$$D = D_0 \cdot \text{Exp} \left(-1 - \frac{\ln 2}{T_{1/2}} \cdot \frac{t}{t_{\text{ref}}} \right) = 8 \text{cGy/hr} \cdot \left(\frac{1}{3} \cdot \frac{1}{2} \right) \times \left(1 - e^{-\frac{\ln 2}{T_{1/2}} \cdot \frac{t}{t_{\text{ref}}}} \right)$$

ABR Written Exam Questions for AAPM SC Chapter Notebook

Advice:

Study the following:

- (1) Bushberg's Diagnostic Radiology Physics - this is the best choice (and one of the co-author's was an examiner for the orals- Seibert: If you can't use this book, then use Christiansen's Introduction to Radiological Physics all the way through including shielding and radiation Dose
- (2) Sorensen and Phelps for chapters on Counting Statistics
- (3) Hall for Radiobiology and especially effects of radiation
- (4) John's and Cunningham - Chapters 1-9 and 15 (radiation protection)
- (5) Regs- specifically NCRP 116 (not 93) for dose limits for workers and others
- (6) Important to remember that this is closed book and that NO constants or tables are given. Several times I had to convert from rad to Gray and remember that $1 \text{ rad} = 1 \text{ cGy}$. But the problems are often given to make sure that you can manipulate the units correctly (values given in mGy or mrad and converted to Gy, etc.). There was also a problem that required the speed of sound in water and the value was not given - You

HAVE TO MEMORIZE THESE!

- (7) The format of the 97 exam was: 50 questions for the clinical part in 1 hour, but everyone finished with plenty of time; 150 questions for the general part - 25 moderate, 25 difficult and 100 T/F questions; 150 questions for the diagnostic part - 25 moderate, 25 difficult and 100 T/F. The T/F questions always went pretty fast and I think I did all 100 in less than an hour. This allows you to concentrate on the more difficult (and more weighted) questions. Some questions just appeared to be impossible or could take up a LOT of time to figure out; don't be afraid to guess and move on.

Hi Peter :

These are some of the questions that appeared on PART I of the ABR physics exam, which I took in 1998. I don't remember the exact questions but I recall the general topics.

Anatomy section -

1. Question on the heart ejection fraction - information about volumes of blood pumped during diastole and systole were provided.
2. T/F question on the mantle field anatomy.
3. A CT scan of the pelvis was provided and various structures were labeled for identification.
4. Question on the digestive tract and about different enzymes used to digest various types of food.
5. An MRI brain scan was provided and we were asked to determine whether it was T1 or T2-weighted. Several questions then followed and relied upon whether the scan was T1 or T2-weighted. This meant that if you answered the first part wrong, you would probably get all the others wrong.

The anatomy section consisted of about 100 questions and was administered before the general physics exam. The allotted time was 1.5 hr, if I remember correctly, but most everyone was done within 1 hour. This section of the exam was fairly straightforward and there appeared to be no major pitfalls.

General Physics Section -

1. Question on calculating the neutron activation in a material.
2. A circuit consisting of a resistor and an inductor was provided and two questions were asked relating to the currents and voltages at different times after opening and closing the circuit.
3. Question on calculating the rotational inertia of a disk.
4. Question on the rotational kinetic energy - question related to rotational kinematics.
5. An integral with log function was provided and required evaluation.
6. Several questions relating to diagnostic physics, including questions on diagnostic x-ray target currents and output, shielding, etc.
7. Several questions on the linear quadratic model; graphs were provided and questions were asked relating to alpha, beta, fractionation, etc.
8. A few questions relating to the use of the equation e^{rx} in various materials and for various energies.
9. A nuclear medicine T/F question on well chambers and the types of radiations observed with various sources, such as Na-22.
10. A T/F question on the F-factor.
11. A T/F question on the gamma constant and various factors it is dependent on.
12. Several questions on statistics relating to the mean and standard deviation.
13. A question on counting statistics relating to counts from a detector, background counts, etc.

The general physics test consisted of 5 and 15 point questions and about 50 T/F type questions. The total no. was about 130 questions. The 5 point questions and T/F were fairly straightforward, but the 15 point questions were very challenging.

Sorry about not being able to provide more information. I will write things down right after I take part II this year.

$$T = \frac{1}{2} \rho R^2$$

$$T = \frac{1}{2} M L^2$$

$$M \text{ GY}$$

TEST: ABR Therapeutic Physics Exam

Part - I

September 2000

TEST DATE:

75 multiple choice questions to be answered in about 3 hours
The first 50 questions were "easy" and worth 1 point each.
The last 25 questions were "hard" and worth 3 points each.

Easy-type questions

- (1) Given a picture of non-wedged profile scans obtained using a scanning water tank, question asked what was wrong with the superficial-most profile (which appeared somewhat wavy in comparison to the others). *wave wave*
- (2) One question regarding the spatial resolution of MOSFET detectors. Possible answers were in units of μm .

- (3) Define wedge angle. *the angle through which an isodose curve is tilted at the central ray of a beam at a specific depth ($d=10\text{cm}$)*
- (4) State which measuring device would be most appropriate for simulator shielding measurements for a radiation protection survey. Possible answers included different types of survey instruments (e.g., G-M tube, handheld ion chamber) as well as different sizes of ion chambers (e.g., 1 cc, 10 cc, or 100 cc).

- (5) How much dose is delivered from 1-125 after 45 days given its half-life and initial dose rate? $D = \delta \cdot T_{1/2} (1 - e^{-\frac{\ln 2}{T_{1/2}}}) = D \cdot (59.4 \times 1.46) \times (1 - e^{-\frac{\ln 2}{50}}) = 59.4 \text{ Gy}$

- (6) One question about reasons for using a parallel-plate chamber for measuring output of a 4 MV photon beam. *gradient effects*

- (7) What is the NRC-required frequency of sealed source inventory?

- (8) One question related to a skyshine shielding calculation where person only needed to recall the formula for computing steradians given a diameter subtended and distance from source. $A_s = 2\pi(1 - \cos\theta)$

- W_{TB1} = D_{TB1} \cdot \theta^2*
- How much does a linac's workload increase for a TBI given the treatment distance, rep rate at isocenter, and dose to be delivered to the patient per week. $W_1 = D \cdot \eta \cdot W$ for leakage
- Other should be same?*

- (9) Most probable use for a "9" "rem counter" (as described by Kalm on page 495 of 1994 ed of *The Physics of Radiation Therapy*). Question was about what this instrument was used to detect. Possible answers included photons, thermal neutrons, fast neutrons, combinations of neutrons and photons, etc.

- Scatter* \rightarrow rem counter \rightarrow Bf_3 proportional counter \rightarrow *surrounded by 4 inch sphere*

- TBI workload* \downarrow
- Ex: Non TBI $W = 700 \text{ cGy/week}$ $T = 0.21$! radiation-loaded polyethylene sphere*
- TBI dose = 120 cGy/week $\theta = 4\pi$. $\frac{0.21}{4\pi} = 0.021$*
- $W_{TBI} = \sqrt{200 + 12 \times 4^2} = 200 + 102 = 255 \text{ cGy/week}$ Thermal neutron - versus neutron

- W scatter from TBI patient, TBI barrier = 255 cGy/week*
- W scatter from 100 cGy barrier = 300 cGy/week*
- W leakage = 300 + 192 = 492 cGy/week*

- (11) Question on ICRU Report 50 diagram outlining the GTV, CTV, PTV, TV, & IV. Person was given an illustration of this diagram and asked to which volume the arrow was pointing. (For this exam it was pointing to the PTV.) *IV → 100 cGy*
- (12) One question about the uses and limitations of LiF TLD detectors for use in a radiation therapy department. Specifically, their accuracy, linearity, etc. *low energy dependency*
- (13) One question about what is not modeled for a beam for a 3-D treatment planning computer. Possible answers included upper collimator jaws, lower collimator jaws, target, monitor chambers, or the mirror. (Answer: mirror since the beam doses not pass through the mirror, and it does not act as a beam modifier.)
- (14) What's the TG-34 recommended dose limit to a pacemaker? (200 cGy) *200*
- (15) What's the dose to a kidney that will cause irreparable damage? *200 cGy* $\left\{ \begin{array}{l} 200 \text{ cGy} \rightarrow 10.5\% \\ 200 \text{ cGy} \rightarrow 70.5\% \end{array} \right.$
- (16) One question on use of bubble-type neutron detectors. *passive type both inside/outside room, but dose in the beam*
- (17) Which of the following can occur that does not require a full re-calibration of all beams and beam scanning for a linac? (possible answers: changing klystron, bending magnet replacement, MU chamber replacement, target replacement, or waveguide replacement)
- (18) Simple inhomogeneity calculations for photons. You're given physical densities, electron densities, and mass attenuation coefficients. $\Delta f = \rho / (1 - \mu)$ *1 - CT*
- (19) About 5 or 6 questions on TG-51. *3% inhomogeneity*
- (20) One TG-56 question about coefficient of variation of measured seed strength $\Rightarrow 3\%$ report $\Rightarrow 5\%$ *inhalation*
- Other things to note: Both old and most recent units used throughout for brachytherapy and radiation protection problems. Expect to have to convert units. *At least 10% of seeds to check*
- Hard-type questions** or $\approx 100\%$ or 2 problems *(3 points each)*
- (1) Several inhomogeneity calculations for electrons and photons were asked.
- (2) Usually given physical densities, electron densities, and mass attenuation coefficients. These were a little tougher than the one or two given in the easy-type questions, requiring one to perform more steps or to solve using a slightly different method to arrive at the answer requested.

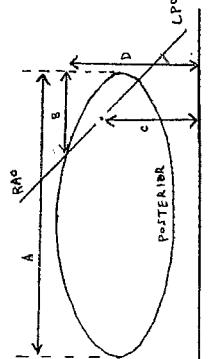
HDR Calibration (RH) @ 1m. in air

$$S_{\text{RH}} = 8.76 \times 10^3 \times (1^2 \text{ m}^2/\text{hr}) \quad (8)$$

$$S_{\text{RH}} = I \cdot P_{\text{Pec}} \cdot N_{\text{C}} \cdot A_{\text{air}} \cdot P_{\text{corr}}$$

(2) A couple of questions using %DD and dose calculations for superficial units.

(3) Given the following tangential setup and measurements, what must be the LPO gantry angle. Although not stated, one must assume IEC gantry angle convention and directly opposed beams (at my workplace, we usually make our posterior borders coplanar instead of being directly opposed by 180°). Also, the field size was given. The axis drawn on the diagram did not indicate if it was the central axis or the posterior border of the field. I assumed it was the central axis since there was somewhat of an isocenter dot drawn on the diagram.



Given T/O set-up with a single 15 mgRaEq source in one ovoid, what's the dose to a point off the axis of the tandem and superior to the flange. This arrangement was placed on a grid to give one the distances needed to perform the calculation.

(4) A mixed beam was used to deliver a particular dose to 3 cm depth in tissue. The beams used were the 9 MeV electron beam and the 6 MV photon beam. The %DD and surface doses were given in a table for both beams. The requested total dose was 55 Gy to 3 cm depth and 40 Gy to the skin's surface. What would be the dose for each beam? (I had to set up a system of 2 equations and 2 unknowns to arrive at one of the possible solutions.)

(5) Several basic dosimetry questions requiring one to calculate MU to be delivered using %DD and TAR tables for a 6 MV photon beam and a Co-60 unit, including one at an extended distance.

(6) Some legitimate, clinically relevant questions on make-up doses for misstreated patients. The setups included wedges; parallel-opposed beams with and without wedges, switching of MU in calculations, calculating to wrong isodose line, etc. The dose given to a particular isodose line had to be determined based on the dosimetric error(s) made, and the correct # of MU had to be calculated for a particular field to finish the treatment in so many fractions. (This is a typical, easy problem for any clinical physicist, but can require a couple minutes longer than other "hard" problems.)

$$\overline{D}_{\text{mod}} = M \cdot N_{\text{sp}} \cdot \left(\frac{t}{P}\right)_{\text{air}} \cdot P_{\text{in}} \cdot P_{\text{op}} \cdot P_{\text{mult}}$$

Had to determine if a linear output check was a certain percentage high or low, or exactly right. The necessary calibration information was given (e.g., temperature, pressure, electrometer reading, electrometer calibration factor, chamber calibration factor, stopping power ratio, etc.). TG-211

Had to determine if measured activity of an HDR source agreed with its certificate value. Had to convert units and decay certificate source activity. Measurement was done in air and 1 meter from source. You were given a calibration factor of the instrument used to make the measurement. The question wanted to know if measured value was equal to decayed certificate activity, or a certain percentage high or low.

(7) Several shielding questions were asked.

One dealt with a maze-less high-energy linac room, and wanted to know what material would be used to patch a small opening near the door. Possible solutions included lead, steel, aluminum, borated polyethylene, etc.

One question dealt with a treatment room for a patient being treated with about 150 mCi of Cs-137. Assuming 50% attenuation by the patient and the nearest wall was 2.5 meters away, how many extra HVLs were needed to reduce the exposure level to meet NRC regulations for the occupied adjacent room? The exposure rate constant was provided, but its units were incorrect. The exam gave 3.26 R cm²/mCi hr instead of 3.26 R cm²/mCi hr. All answers were ≥ 1 HVL.

Other shielding questions which required one to calculate μ using the provided TVL, and then determine the correct # of HVLs needed to reduce the exposure level to a requested level, or a level dictated by conventional (NRC) shielding requirements.

$$150 \text{ mCi} \cdot (3.26 \text{ R cm}^2/\text{mCi hr}) \cdot 0.5 \cdot \left(\frac{1}{2}\right)^{\text{HVL}} \cdot \left(\frac{1}{250}\right)^2 = 2 \text{ mR/hr}$$

$$0.003912 \left(\frac{1}{2}\right)^{\text{HVL}} = 0.002 \text{ R/hr}$$

$$\left(\frac{1}{2}\right)^{\text{HVL}} = 0.1$$

$$\text{HVL} = 1$$

$$\text{HVL} = \frac{1}{\ln(0.1)}$$

$$D_{\text{op}} + D_{\text{se}} = 40$$

$$\left(\frac{1}{10}\right)^n = B$$

$$n = \left(-\log B\right) / \log \left(\frac{1}{2}\right)$$

$$n = -\log B / \log 2$$

$\lambda_{\text{al}} \Rightarrow 19 \text{ water}$

$$1/\text{cc} = 4.19 J$$

Specific heat \Rightarrow # of cal to ΔT by 1°C

$$\text{ice } \frac{1}{2}$$

Steel 1/8

ABR 2000 - Part 1 - Physics

1. Calculate the kerma deposited by a beam with a photon flux of X and the following values for $\mu/\mu_0/\rho$.

2. Which of the following do not influence the MTF of film?

3. The threshold of hearing is $X \text{ W/m}^2$. A sound of $Y \text{ W/m}^2$ corresponds to how many dB?

4. Electron capture competes with which of the following processes? β^+

5. Decay scheme is shown. Not all of the energies are labeled. You are asked to deduce total energy of the decay. The key here is to simply know the threshold energy of Beta plus decay.

6. What is natural background per year at sea level including radon? $0.94 - 0.28 \approx 0.66$

7. A 16 bit computer can access how many locations?

8. One hexadecimal digit can be used to count up to what number?

9. Which of the following would have the highest LET? γ particle.

10. Question on Blackbody radiation.

11. Which of the following lasers is not useful for fiber optic transmission? A series of laser types were listed along with the corresponding wavelength. (CO_2)

12. If 0.1 kg of water is cooled from 40°C to -80°C, how much energy is lost? Given specific heat of water, specific heat of ice, and an additional constant (thermal fusion constant?).

13. According to the uncertainty principle which of the following cannot be measured simultaneously? $\text{position} \leftrightarrow \text{momentum}$.

14. The area of a copper plate is 0.1 m^2 . The coefficient of linear expansion is provided. If the temperature increases from 22°C to 100°C, what is the new area?

15. If the workload of a machine doubles, by how much must the barrier thickness be increased?

- a. one half value layer

16. How long can one spend 50cm from a patient with a 60mg radium equivalent implant, and not exceed the occupational limit applied to one week?

$$\begin{aligned} \text{Rate} &= \frac{A}{t} = \frac{60 \text{ mg}}{T} = \frac{60 \times 10^{-3} \text{ g}}{T} = \frac{60 \times 10^{-3} \text{ g}}{T \times 10^3 \text{ sec}} = \frac{60 \times 10^{-6} \text{ g}}{T \text{ sec}} \\ \text{Dose} &= (\text{Rate}) \times \text{Time} = (60 \times 10^{-6} \text{ g/sec}) \times \frac{1}{50} \times T \text{ sec} = 1.2 \times 10^{-6} \text{ g} \end{aligned}$$

$$T = 4.856 \text{ hr}$$

$$f = F(m-1) = F(\frac{SD}{SD-1})$$

parametrized

$$R_B = \frac{19200}{30} = 640 \text{ cpm}$$

$$R_S = 1000 - 640 = 360 \text{ cpm}$$

17. Counting statistics. The gross count for 10 minutes was 10000 counts. The background count for 30 minutes was 1920 counts. What is the net count rate and its standard deviation?

18. Given the area of a detector and its distance from the source. What is the detector efficiency?

19. Assume a binomial distribution. 4 measurements are taken with a maximum deviation between 2 of 10%. What is the standard deviation?

20. Question on the stop of a camera. $f \neq 2 \text{ diameter} = \frac{f}{2}$

21. Given attenuation coefficient. What percentage of the incident photons is absorbed between a depth of 1 and 2 cm?

22. What is the increase in the total equivalent dose for an AP versus a PA radiograph?

23. A nonparalyzable records 450 cpm. It has a deadline of x . What is the true count rate?

24. Dq = $\rho_0 / (1 - \rho_0 t)$ \Rightarrow Dq = $\rho_0 e^{-\rho_0 t}$ \Rightarrow Dq = $0.5 \text{ Gy} / (1 - 0.5 e^{-0.5 t})$

25. A-bomb survival data is provided. What is the increase in relative risk for cancer for those who received greater than 0.1 Gy? 0.8%

26. For a certain diagnostic test, you are provided with the number of true positives, true negatives, false positives, and false negatives. You are asked to determine the sensitivity of the test. $S = \frac{TP}{TP + FN}$

27. Effective half-life problem.

28. Doppler effect. Given velocity of train, calculate frequency of a sound measured by a stationary observer.

29. 1e15 bytes is $\text{y/petabyte, terabyte, gigabyte...}$

30. question involving rms voltage

$\sqrt{V_{rms}} = \frac{1}{2} V_{peak} \text{ for sine wave form.}$

ABMP Part III (July 2000)
Chicago

♦ Similar questions to those listed in this book for ABMP 1999, part II. Also:

♦ Define brachytherapy functions, g, F, & $\lambda \rightarrow$ dose rate constant in water (cm^{-2})

♦ mid-point @ 1m bilious. $g_{\text{mid}} \approx 1375 \text{ rad}$ $\lambda \rightarrow$ radial dose function

♦ Prescribed doses in TBI w/ photon and electron $F = 20$ anisotropy function

♦ Prescribed doses in SPS, SRT, breast, prostate, seminoma

♦ 3-field treatment, 180cGy, gantry 120deg apart, equally weighted, lateral beams pass through 6cm lung, what dose actually absorbed? higher dose.

♦ particle accelerators can accelerate positive ions, neg ions, particles with neutral charge

♦ Ir-192 transportation: Dept. of transportation oversees it? Transportation index must match exposure rate? Only sample batches need leakage testing? Activity of Ir-192 must be indicated outside the box?

♦ 6x, 100cm SSD, d=10cm, PDD=73. Same beam used for SAD. What's TMR @ d=10cm?

$TMR = PDD(f, r, d) / (PDD(f) * PDD(d))$

♦ Brachytherapy definitions: anisotropy geometry / radial functions

♦ Use of re-entrant ion chamber in brachytherapy source calibration

♦ Earlier NIST shortcoming in anisotropy function calculation of 1-125 due to neglecting what?

♦ MPD per hr, per year, next to a linac, during Co-60 operation (on and off)

♦ A feature in monthly QA of film (when using Co-60?) that's not used in Linac QA

♦ Good luck!

typical DR for point A

point B bladder surface

uterus

water

photo energy (MeV)	T	S	T
0.01	0.5	5	0
0.026	50	50	0
0.050	0	100	0
0.150	0	50	50
24	0	50	50

ABMP 2001 - Therapy physics (part II)

Note: topics identified as "matching" had 3 to 4 questions a piece

BASIC RADIATION PHYSICS

Given 200 cgy delivered to volume of tissue, different for photons vs. e-? depend on energy? depend on issue?

Known energy where photoelectric and Compton interactions are ~equally likely

Properties of Co-60 decay $T_{1/2} = 5.24 \text{ years}$ $\lambda = 0.67 \text{ min}^{-1}$ $P_{\text{disintegration}} = 1.33 \text{ MeV} \Rightarrow 1.25 \text{ MeV}$

EQUIPMENT

If knew volume of chamber, which parameters from TG-21 are not needed

If have 2 chambers of same model & manufacturer, which TG-21 parameters are likely to be different (list included on N.A. App. Note)

Put the parts in tx head in order (list included: monitor chamber, target, collimators, waveguide, mirror, waveguide, matching, match imac parts with appropriate functions (list included: magnetron, circulator, waveguide...)

Given MHz, calculate size of each microwave cavity KV (voltage) vs. beam size, heat effect, output proportional to...

NV (transmission line properties) $\propto \sqrt{f}$ $\propto \sqrt{P}$ $\propto \sqrt{I}$ $\propto \sqrt{E}$ $\propto \sqrt{Z}$ $\propto \sqrt{L}$ $\propto \sqrt{A}$ $\propto \sqrt{d}$ $\propto \sqrt{R}$ $\propto \sqrt{C}$ $\propto \sqrt{G}$ $\propto \sqrt{B}$ $\propto \sqrt{H}$ $\propto \sqrt{F}$ $\propto \sqrt{M}$ $\propto \sqrt{N}$ $\propto \sqrt{S}$ $\propto \sqrt{T}$ $\propto \sqrt{U}$ $\propto \sqrt{V}$ $\propto \sqrt{W}$ $\propto \sqrt{X}$ $\propto \sqrt{Y}$ $\propto \sqrt{Z}$ $\propto \sqrt{A}$ $\propto \sqrt{B}$ $\propto \sqrt{C}$ $\propto \sqrt{D}$ $\propto \sqrt{E}$ $\propto \sqrt{F}$ $\propto \sqrt{G}$ $\propto \sqrt{H}$ $\propto \sqrt{I}$ $\propto \sqrt{J}$ $\propto \sqrt{K}$ $\propto \sqrt{L}$ $\propto \sqrt{M}$ $\propto \sqrt{N}$ $\propto \sqrt{O}$ $\propto \sqrt{P}$ $\propto \sqrt{Q}$ $\propto \sqrt{R}$ $\propto \sqrt{S}$ $\propto \sqrt{T}$ $\propto \sqrt{U}$ $\propto \sqrt{V}$ $\propto \sqrt{W}$ $\propto \sqrt{X}$ $\propto \sqrt{Y}$ $\propto \sqrt{Z}$ $\propto 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Calculate dose at cord given dose at prescription depth
Calculate total dose given several beams which traverse several cm of lung

% change in PDD for 5 cm error in setup

SAD to SSD setup, changes

Dose calc for 4-field pelvis given TMR and depths

Calc MU/deg factor for arc of certain angle

Calc dose to point under block given diagram, TMRs for open & blocked fields, block transmission, dose to point in unblocked portion of field

Gap calc (matching two hemi-body set-ups)

Craniospinal junction – methods for compensating fields

For cranial field without compensation, which point receives most dose (axilla, cervical nodes...)

Combined photon/electron for parotid (who combine, typical ratio, ...)

Wedge factor (Δ with depth, Δ with field size, dynamic wedge issues...)

Compensators (list included, independent of depth, independent of field size, uses less than equivalent thickness of tissue, brass comparable to cerro)

Matching: match the best diagnostic study (CT, MRI...) with each anatomic site (prostate, glioblastoma multiforme...)

Disadvantages of using MRI for RT/P

Factors needed to determine size of tumor (TSD, TFD, etc)

What can be determined from DVH

General pros and cons of MLC

3D BEV planning issues

Critical structures relevant to backscatter from lead shields in electron beams (e.g. buccal mucosa)

SPECIAL TREATMENT PROCEDURES

Matching, match the special (IMRT, SRS, HDR, TSET, TBI) with the disease (myct fungoides, leukemia, glioblastoma multiforme, bile duct carcinoma)

Glen TMRs for neck and abdomen, calc lead to give equal midplane doses for TBI

Table requirements for stereotactic radiosurgery

Purpose of dual fields or TSET

Methods of IMRT (list included wedge, dMLC, partial transmission blocks...)

How much is the energy of an electron beam for TSET degraded by 3 m of air

RADIATION SAFETY

Fetal irradiation (know what happens when irradiate during preimplantation vs. organogenesis, whether neurological damage results if radiate during weeks 8-15...)

Primary barrier calc

Neutron detectors

Matching, use & occupancy factors

HDR emergency procedures

Packaging labeling/transportation (know definition of TI, what needs to be on label, ...)

Source leakage limit

When can pt who received pharmaceutical leave hospital

Door shielding - What is needed from inside of door to outside

Know average energy of neutron distribution

Misadministrations – know %

Dose to fetus from mantle field of pregnant patient comes from...

QUALITY ASSURANCE

TG-40: includes QA for which list included brachy sources, chart review, CT sim...)

TG-40: Co-60 monthly QA tasks

TG-40: tasks to perform each time an electron/teletron chamber system is used

TG-25: know specs for flatness, symmetry, uniformity index

BIOLOGICAL AND CLINICAL CONCEPTS

TGs/TD stands for, ..., second 5 stands for...)

Common late effects for thoracic irradiation

Matching: Critical structures (...) associated with treatment sites (larynx, ...)

Be able to put in order of escalating dose for cure (list included: breast, Hodgkin's, seminoma, prostate)

Matching: match TD₅₀ values with correct organ (list included: fetus, lung, optic chiasm...)

Know what PTV includes/represents

Meaning of c/β ratio

Do on survival curve represents...

Matching: match parts (larynx, choroid, ...) with anatomy (lung, eye, ...)

Angular momentum, for particle:

$$L = r \times p$$

linear momentum

$$= mv \cdot r \sin\theta$$

for circular: $L = mvr$

ABR 2001 Exams
As a general strategy I would recommend looking into old RAPHEX exams. Do as many as possible. I also found that there were several questions posted on the ABR web site that looked very similar to those listed in the exam.

General Exam

For this section, the key is to study Hendie's book: Medical Imaging Physics

- If the efficiency of a 10 atm GM counter is 90% and drops to 1 atm, what is the new efficiency
- Detector has count rate of X
- Neutron activation, what is the activity of a ^{59}Co source irradiated in a neutron flux with an activity of X
- Radiation protection question
- Statistics question
- Voltage question similar to demo question on website. What is the electric field at 0.5 cm from electrode.
- Survival fraction given D_0, n , what is D_q
- Calculate speed of film given HD curve

Radiation Oncology

Kahn's book: The physics of radiation therapy is the key reference for this exam.

- What is the dose at point X m from source
- Match the energy with isotope
- Numerous questions regarding shielding for brachytherapy
- Given the basic calibration data such as charge, N_i, Pion, Propl, etc what is the dose / MU value for the ion chamber. This equation required you to basically plug in the TG-21 values and compare your answer to the five choices.
- MU calculation involving isocentric treatment plan with SAD = 100 cm. Required to look up data from several tables and determine what the correct MU is.
- MU calculation involving extended SSD calculation. This required knowledge of Kahn's method for extended SSD treatments. The SSD was 110 cm.
- Shielding calculation
- Tangential breast treatment question where you were required to determine the angle between the CAX of the two tangential fields.
- Single TG-40 question
- Several questions regarding Federal regulations etc.

- $\Omega \rightarrow$ narrow beam width \rightarrow sharper
 $\Rightarrow \downarrow$ tangential depth (LT)
 \Rightarrow less divergence (Θ_s)
- $\Omega \downarrow$ broad \rightarrow better axial resolution

- $f \uparrow \Rightarrow$ better axial resolution.
 $\Rightarrow \downarrow$ tangential depth (LT)
 \Rightarrow less divergence (Θ_s)
- $\Omega \uparrow$ if tall plan
 \uparrow uptake half life
 $\frac{T_{1/2}}{T_{1/2}}$

- uptake is not rapid in compound with TP
 \Rightarrow $A_u = 1.44 A_0 e^{-\frac{t}{T_{1/2}}} (T_{1/2})$ uptake
 $\frac{T_{1/2}}{T_{1/2}}$ effective uptake
 $\frac{T_{1/2}}{T_{1/2}}$ half-life

ABR Written Exam 2002

moment of inertia. (rotational inertia)

General Physics:

- A ball is thrown into the air with a given velocity. When will it reach its peak?
- A question about the angular momentum.
- A weight is string on a beam that is supported by two columns. Given the location of the weight on the beam, calculate the force on each beam.

- Q. Electron travels from the cathode to anode (Voltage and distance was given). How long it take for the electron to travel this distance.
- Given the initial activity and the activity at a time t in a biological system (e.g. the effective half-life) and the physics half-life, calculate the biological half-life.

- Part (40 %) of the activity is lost with a effective half-life of X . The other part (60%) is cleared with a different effective half life, calculate the activity at a time t.
- $A = A_0 e^{-\frac{t}{T_{1/2}}}$

- Two isotopes have a given count rate in window A and B respectively. For a mixture calculate the activity of isotope B.

- A ultrasound beam impinges at an angle X onto an interface. What is the angle of the reflected beam (despite were given)
- A question about the pulse repetition frequency of an ultrasound transducer. The focal depth was given

- $\Sigma Q = \frac{1}{2} \alpha (L - d/4)$
- At a given frequency a ultrasound beam is attenuated by 20 dB. If the frequency changes from 2 to 4 MHz, what is the new attenuation.

- RC circuits.
- Compton scattering. Angle and initial energy are given. Calculate energy of scattered photon.
- The hex equivalent to a binomial number.

- Calculation of accumulated dose $A = A_0 e^{-kt}$ $\rightarrow T_{1/2} = 60.2$ days
- What is the accumulated dose of an I-125 implant after 60 days.

$$A = \int_D^{\infty} A(t) dt$$

$$= 1.44 T_{1/2} A_0$$

Do I painting between open and wedge fields: Not $N_W = 1$

$$W_W = \frac{\text{tangoff}}{\tan(\theta)} \quad W_0 = 1 - W_W$$

$$W_W = \frac{\tan 30^\circ}{\tan 60^\circ} = 0.333 \quad W_0 = 1 - 0.333 = 0.667$$

$$\text{② } M_{WW} = \frac{Dose_{WW}}{TAR \cdot Sc \cdot WF(WHF)} \quad \Rightarrow \quad \frac{M_{WW}}{M_{WW}} = \frac{W_0 \cdot WF \cdot WHF}{W_W}$$

$$M_{WW} = \frac{Dose_{WW}}{TAR \cdot Sc \cdot WF}$$

1. There are three hours to do the test. Questions #1-50 make up 40% of the grade.
Questions #51-75 make up 60% of the test. You will have enough time to finish the test if you work fast.

- ② How often do you have to re-measure the room shielding for HDR? *During initial survey \rightarrow after source change*

- ③ What happen in after the linacron fired?

- ④ Given the attenuation coefficient of 0.018 cm²/gm, depth of 5.5cm with dmax of 2.0cm, What is the percent depth dose at depth? TSD=100

$$PDD = 100 \left(\frac{f(dn)}{f(TA)} \right)^2 e^{-0.018(5.5-2)} = 100 \left(\frac{f(5.5)}{f(2)} \right)^2 e^{-0.018(3.5)} = 87.8\%$$

6.  film \rightarrow dose distribution

\Rightarrow collector based & source \rightarrow free air ion chamber

\Rightarrow collector based \rightarrow well-type ionization chamber

\Rightarrow relative output \rightarrow relative output \rightarrow well-type chamber

7. What is the best device for IVBT source calibration? *Well-type ionization chamber*

8. According to the task group, where is the reference point for IVBT? (2 mm from source center) *2mm from source center and for the peripheral extent, 2mm beyond source center*

9. Given Field AP-PA 10.4cm and Sup-Inf 16.8 cm with SAD setup, find the table the overage linear radius.

10. Given source size 3cm, SSD of 100cm, depth of 10cm and SDD of 30cm, calculate the physical penumbra. $P_{pen} = \frac{S}{S + S_{pen}} \cdot \frac{100 + 10 - 30}{30} = 3 \times \frac{100 + 10 - 30}{30} = 80cm$

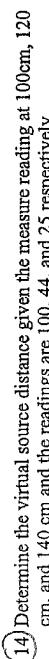
11. A point is 2 cm outside of a 10x10 treatment field at 10cm depth, what % of dose does it get? $D_p = \frac{1}{D_{10cm}} \cdot \frac{1}{2} [S_p(24.10) + P(D(4.10), 10) - S_p(4.10)] P(D(4.10), 10) = 55.0\%$

12. Patient simulation was done with 17.5 x 22, 100 SAD setup, thickness of 22 cm, film at 130cm. It was decided that the patient will be treated with 100 cm SSD setup instead. What magnification factor do you use for the Sim film to cut the blocks? $(130/100) \times 11$

13. Patient was treated with 100 cm SAD setup with thickness separation of 22 cm. Patient is moved to cobalt with 80 cm SSD setup. What is the new field side?

14. Determine the virtual source distance given the measure reading at 100cm, 120 cm, and 140 cm and the readings are 100, 44, and 25 respectively.

15. A given dose rate in air at 40° from the superficial x-ray source 125kVp, 10RmAs. What is the dose rate at 2cm depth (Pdd=0.6, Bsf=1.15, fineid=0.9)

16.  $\rho(R_{ff} \cdot fineid) \cdot Bsf \cdot PDD$

17. $\rho(R_{ff})^2 = \frac{100}{44} \quad (\frac{100}{10})^2 = \frac{100}{25}$

18. $\rho(R_{ff}) = \sqrt{\frac{100}{25}} = 2$

19. $\rho(R_{ff}) \cdot fineid = 2 \times 0.9 = 1.8$

20. $\rho(R_{ff}) \cdot Bsf = 1.8 \times 1.15 = 2.07$

21. $\rho(R_{ff}) \cdot Bsf \cdot PDD = 2.07 \times 0.6 = 1.242$

22. $\rho(R_{ff}) \cdot Bsf \cdot PDD = 1.242 \times 1.15 \times 0.9 = 1.36cm$

16. Given the TVL of steel and concrete. The calculated shielding wall thickness needed was 66 inches of concrete. You have only 36 in for wall space, how much concrete should be replace by the steel?

Lot of Shielding problems

17. Basically, just calculate the transmitting factor and determine how many TVL needed. You have to watch out the mix units i.e. time in min, week etc...Also, some linac head leakage and scatter problems.

18. Patient is being treated with SAD setup with iso at 9 cm depth, calculate the exit dose giving the PDD or TMR at 9 and 18 cm. depth.

19. How much charge would you get for a given exposure rate and chamber size, given: IR-25.8e-4 C/Kg, air density = 1.293e-3 Kg/cm³, chamber size = 0.19 cm³. $\delta = \kappa M \Rightarrow \kappa (R) \cdot 2.58e-4 \cdot 1.293e-3 \cdot 0.19cm^3 =$

20. There is a 1 mm crack on the linac vault and you a large ion chamber to measure the exposure rate of 1 mR/hr. You move the chamber away from the crack behind the "good" wall and the exposure rate is 0.5 mR/hr. Is your exposure rate at the crack smaller or larger than 1 mR/hr? *larger*

21. Patient treated with 3 fields, equally weighted, 180cGy. Two posterior fields go through 9 cm of lung and SSD is 92 cm. If you don't correct for lung inhomogeneity, what is the percent error at isocenter?

22. You have a universal 60 degree wedge with the wedge factor of 0.5. You want to use a 30 degree wedge. What is the ratio of MU for the open to wedge field?

- A few beam spoiler questions to assure adequate dose to *shoulder* $M_{wedge} = \frac{60}{50} \cdot \frac{Sc}{Sp} \cdot \frac{TMR(q)}{TMR(q+0.25)}$

23. For treating breast tangents-something 10MV is used with beam spoiler. Why? *When higher energy is used, a beam spoiler or bolus may be used*

24. A few electron obliquity question- ie. How does it affect surface dose, depth dose etc... *decrease depth dose, shift dose to surface*

25. Given aluminum and water mass and electron density, determine how thick the aluminum compensation should be to compensate 5 cm of tissue. Info given: Water: 3.2e23 e/g, 1g/cc, Al: 2.9e23 e/g, 2.7 g/cc. $\Rightarrow t_0 = \left(\frac{1}{\rho_{Al}} \right) \cdot T_{air} \cdot 0.7$

26. 18 MV photon linac, what is the largest contribution to exposure behind the gantry stand. Is it patient scatter, wall scatter, col scatter, head leakage etc... *patient scatter*

27. TG 40, how often do you check electron output? *monthly* 2%

28. TG 21 and TG 51, what is the % difference in measurement and which is higher, lower, or the same? *TG51 1% higher photon*

29. $\frac{dose}{dose} = \frac{3\%}{2\%}$

30. $\frac{dose}{dose} = \frac{3\%}{2\%}$

31. $\frac{dose}{dose} = \frac{3\%}{2\%}$

32. $\frac{dose}{dose} = \frac{3\%}{2\%}$

2004 ABR Written timing considerations. I put a lot of effort not just into learning the material but into learning fast ways to solve problems. It's not good enough if you know how to solve a problem but it takes twice the allocated time per question. Here is how I went with regard to time. I simply divided up the allocated time evenly on a per point basis:

Part 1 (General) I was 15-20 minutes ahead at the end of the first 50 one point questions, then picked up at least this amount again during the 25 three pointers. This meant I had something like 45 minutes for review of my flagged questions after completing a first pass – this was much faster than I expected.

Part 1 (Clinical) Similar to candidates from previous years, I finished with plenty of time to spare and actually reviewed every single question.

Part 2 (Therapy) Again I was 15-20 minutes ahead at the end of the first 50 one pointers, but then lost all of this during the 25 three pointers. Some three pointers were quite fast, but quite a number of them were very time consuming eg the TG51 question (number 2 below) has many small calculations within it. I used all but a few minutes to get the exam done, with only a few flagged questions reviewed at the end.

Part 1 (Clinical) Similar to candidates from previous years, I finished with plenty of time to spare and actually reviewed every single question.

This recollection of questions should provide a tremendous help – just like previous candidates recollections did for me. Good Luck!

2004 ABR General Part 1, Written.

1. Two counts of same source, what counts to give 95% chance that the two counts will measure within 4%. (I did 0.04 = 2σ sigma/mu) $N = 2500$

2. Classic Ctrus, Cobs, dead time question.

$$R_d = R_0 / (1 - R_0 \cdot \tau)$$

3. 1600 counts over 4 mins (meas), background 900 counts over 3 mins (measured).

What is the standard deviation in net count rate (cpm)? \sqrt{Q}

4. XXXX n/cm²/sec activates YYYY atoms of ⁵⁹Co per unit time. What is the max activity of ⁶⁰Co (Ci) that can be achieved. (I didn't use the n/cm²/sec)

$$\geq \rho N t = \lambda (N_0) \text{ sec.}$$

5. Chromium neutron activation. Half life given. When is 80% of max activity established.

6. Effective weight if half body (ie below diaphragm) irradiated. Weights for various organs of the body given. Had to know things like lung, breast, thyroid and esophagus are above diaphragm so could remove them from the total.

7. Had an A to B to C decay. (like ⁹⁹Mo – ⁹⁹Tc but not told this). A has 10 hr half life, B has 1 hour, C stable. If only A to start, what is ratio B/A at 5 hours. Answers 1.0, 0.6, 0.3...

$$B/\lambda = e^{-\lambda t} C_0$$

8. In an isotope where gamma emission is forbidden, what else is an alternative – interplay conversion.

9. Decay emits only neutrinos and characteristic x-rays. This is? Electron Capture.

10. P31 1.71Mev gamma ray (given). Best shielding material is \rightarrow lead

A. 1mm Acrylic, B. 1cm Acrylic, C, D, E... Pb of various thicknesses

11. Max dose patient in hospital near "radioactive" patient can receive is A. ~~10~~ Sv, B. 5mSv C...higher doses.

12. Physicist does 50 brachy patients per year. Max dose allowed (per NCRP 116) to ring badge per patient is? $50 \text{ mSv} / 50 = 1 \text{ mSv}$

13. KM anger electron energy given KLM energies (need to know Aug. e emitted from shell where transitioning electron originates) $E_{1e^-} = \frac{1}{2} E_{\gamma}$

13. Electron Anode to cathode time? Given voltage and distance. No mass of electron given. A fast solution involves calculating the final $V = 1/(1-vt^2/c^2)^{1/2}$. Solve for V_{final} , assume $V_{average} = V/2$ (OK if only few 100 keV), then get time from distance.

15. Electron 0.9c, what is the total mass / energy in MeV. Given mo = 0.51 MeV.

$$E = \sqrt{m_0 c^2 + \frac{1}{2} p^2} = \sqrt{m_0 c^2 + 0.51^2} = 1.17 \text{ MeV.}$$

14/3

16. Electron accelerated through 4MV, what velocity? Fast solution again uses $\gamma \rightarrow 0.994$

17. Voltage as a function of radius $V=130\log(r)$. Electric Field strength V/cm at $r=0.5\text{cm}$

18. Unit vector $\hat{X} = i\hat{x} + j\hat{y} + k\hat{z}$

19. Length of $i\hat{i} + j\hat{j} + k\hat{k}$ $\sqrt{3}$

20. Neutron of velocity XXXXX hits and is captured by ^{59}Co nucleus. Before 60Co decays, what is the velocity of the 60Co nucleus (I applied simple cons of momentum) $\frac{1}{\sqrt{1-\frac{m_1}{m_2}}}\frac{v_1}{v_2}$

21. Photons of two different energies of initial number ratio 4 to 1 pass through 20cm of water. μ given for both energies. What is the number ratio of photons after passing through the 20cm of water.

22. Find the μ of a mixture of materials, weight fractions given. μ/p of components given, p of mixture given. Solution: add μ/p by weight fraction then multiply by p of mixture.

23. $\Gamma = 1.5$ (units) for an isotope with 100% efficiency, 1 MeV per decay. What is T (same units) for an isotope with 80% efficiency, 2 photons per decay, each 0.75 MeV?

24. Ultrasound assumes 1540 m/s (given). A layer of fat 2cm thick has actual velocity 1460m/s (given). The ultrasound will measure the fat layer as 7777 cm thick?

A. 1.8 B. 9 C. 2.0 D. 2.1 E. 2.2

25. An OD1 light takes a path at 35 degrees to a linac beam axis. A 10mm thick block tray is inserted into the path of the OD1 perpendicular to the linac beam axis. (no diagram given). What is the lateral shift in the OD1 light. The refractive index of the block tray is 1.5.

26. An ion chamber survey meter has 90% efficiency at 10 atmospheres. The pressure in the chamber drops to 1 atmosphere. What is the new efficiency? Answers started at 21% and went up (ie 9% was not there). If you consider a new linear attenuation coefficient of $1/19^{\text{th}}$ the original I ended with 21%.

27. No CT in parts 1 or 2 (other than anatomy in clinical section)

28. Radiofrequency used in 1 Tesla MRI is... (not given 42.6 MHz/Tesla gyromagnetic ratio) 42.6 MHz was a possible answer.

29. No α/β radiobiology questions (in 1 General or clinical)

30. Do is the ??? on a cell survival curve (question was worded so that the shoulder was not to be considered) A. 37% cell survival, B... other options that didn't look right. This question may have been in the clinical section.

31. Function $y=2x-e^x$. Find the position of the maximum. $\ln 2$

32. $0.1\text{Em} \int_{0}^{\text{Em}} \text{EdE}$. Evaluate the definite integral in terms of Em. 0.4Em^2

33. Calculate the Kinetic energy in a rotating disk given the moment of inertia and the angular velocity in both revolutions/sec and radians/sec. $K_E = \frac{1}{2} I \omega^2$

34. A Petabyte is $10^{15} \times 10^{12}$ bytes
A. $0.98 \text{ E} 1.02 \text{ C} 1.05 \text{ D} 1.07 \text{ E} 1.10$

35. A number (given) of CT images of size 512×512 are compressed with 2.5:1 compression. How long to transfer these images over a T1 line (T1 line bandwidth of XXXX Mbits/sec was given). No information was given about how many grey levels or bits or bytes per pixel. I assumed 8 bits (1 byte) per pixel and got an answer that was available.

36. A number of detector area / distance from source / geometric efficiency problems like others in previous years. Some requiring steradian calculation.

37. Something about specificity is associated with One of the answers was "ROC". Various other statistical terms were provided but didn't appear to have anything to do with sensitivity / specificity. I don't recall anymore, but gave this anyway.

38. A ball is thrown vertically. Question asked for time or height to top – I don't recall. Initial velocity given, but not gravitational acceleration. Velocity given in km/hour.

39. A circuit diagram (diagram given) with a battery in series with a switch, then resistor A then resistor B, then back to battery. Inductor L is in parallel with resistor B only. A long time after the switch is thrown, how much current goes through resistor B? I think the answer is zero as it all goes through the inductor – this was an option.

40. An electrical meter has an internal 5k ohm resistor and registers full scale at 50 micro A. How many meg ohm to insert in series to turn meter into a XXXX range voltmeter? The answers were all tens of a meg ohm apart so you could ignore the effect of the 5k ohm internal resistor and just apply $V=R$.

41. An electrical supply line loading question. Some large piece of electrical equipment has a peak power output of XXXX kW. If this is maintained, but voltage changed from 480V to 240V, by what ratio will supply line losses change. I think the answer is an increase in losses by a factor of $\sqrt{\frac{V_1}{V_2}}$.

42. What is unusable data storage called – A. RAM, B. WORM.

43. Typical shielding in a diagnostic x-ray facility is X mm of lead, ... A. X mm B 5mm ...

29. You have a 6x6 electron cone with a 4x4 insert, what doesn't change? (R practical)

Dose

30. Given an isotope with a known half-life, how long does it take to give 95% of total dose.

$$D = D_0 \cdot e^{-\lambda t} \Rightarrow 0.95 = D_0 \cdot e^{-\frac{\ln 2}{T_{1/2}} t} \Rightarrow 0.95 = (1 - e^{-\frac{\ln 2}{T_{1/2}} t})$$

31. You want to limit a total dose at 1 meter from a patient that has brachytherapy implants to 500 mRem, what is the maximum initial dose rate? I think the isotope was Iodine 125.

$$D_{\text{Total}} = 500 \text{ mRem} \quad 3 \text{ months} \\ D_{\text{Initial}} = 500 \text{ mRem}$$

32. How often do you have to calibrate the barometer according to TG 40?

3 months

photon.

electron

33. TG 40, what % is the flatness of the beam should be?

2%

30%

clayton

34. You are 50 meter above the airport, what % change do you expect to see in pressure?

$$P = P_0 \cdot e^{-\rho g h} = 0.944 P_0$$

35. Given an AP and a Lat film with two points identified, find the distance between them.

$$\sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2} \quad \text{or length projections}$$

Part 1 of the ABR exam 2003

Physics Section:

The CD is great and I thought it was helpful and relevant to what was on the test. Here are some specific questions I remember.

1. There was a question on the STD of a binomial distribution $\int n \cdot P^f \cdot (1-P)^n$.
2. A question on a proton traveling at a certain velocity and colliding with an unknown particle. The velocity of both the proton and particle were given and the question was to figure out the mass of the unknown particle.
3. Converting the energy in joules to mass in a metric ton $1.6 \times 10^{-17} \text{ kg}$
4. A couple of questions on magnification given SID, SOD, OID.
5. A question that gave the rms voltage and a transformer and asked the peak voltage.
6. Given a sound with a certain frequency if you are traveling so fast towards it what frequency do you hear $\sqrt{V - V_s} / \sqrt{V + V_s}$
7. The sensitivity given TP, FP, TN, FN. $\frac{TP}{TP+FN}$
8. How long will it take to transfer a set of images if the transfer rate is X bits/s and the images are 1024 matrix with 8 bits/pixel with transmission overhead of 25%.
9. For a conventional CT, images are 512x512 with 256 shades of grey. How many can be stored on a 5.0 GB storage device without compression?
10. Given you have a solution which is 60% NaCl and contains 45 grams of NaCl. How many grams of NaCl do you have to add to make a 75% NaCl solution?
11. Given a ball shot at a velocity of 2000 km/hr at a 45 degree angle. At what distance will the ball land? Ignore drag forces. $\sqrt{L} = m \cdot v_0 \cdot \sin \theta$
12. Which laser would not be used for fiber optic communication? HeNe, YAG, CO_2 , $10 \mu\text{m}$ surge ray
13. Given Isotope A and B. Isotope B has two times the activity of A and emits a particle with twice the energy. The dose from B will be X times that from A over the same time
14. The entrance dose is 4 Gy and the exit dose is 25mGy on a patient that is 22 cm thick. What is the dose at the middle of the patient? $\frac{1}{2} \cdot 25 \text{ mGy}$
15. Neutron activation.
16. Neutron loses 0.5 of energy per collision. How many collisions to lose x energy?

$$11. \quad \nu \propto \cos \theta. \quad \nu \propto \sin \theta \quad \nu_0 / \sqrt{2} = g t \Rightarrow t = \frac{\nu_0}{\sqrt{2} g} = \frac{\sqrt{2} \nu_0}{g}$$

✓

17. Stats questions. Poisson.
18. Calc. Kerma. They give both energy transfer coeff and attenuation coeff.
19. Calc effective atten Coeff for a given compound
20. Calc the effective Z for a compound
21. Calc the dose to the gas in a dosimeter knowing the energy absorbed in the gas, the volume of the gas and the density of the gas
22. Given a graph of velocity of an object vs. time, calculate the distance that the object traveled over the time period shown in the graph.
23. Given an equation for the potential in x, y, and z, calculate the components of the electric field.
24. Calculate a temperature and pressure correction for an ion chamber given the temperature and pressure at the time of measurement.
25. What is the angle between two vectors u and v if the resultant of the two vectors is perpendicular to u and has a magnitude that is half of v^2
- Clinical Sections:
- I though this was really easy especially after going over the CD. I'll try to remember the only question that I don't remember from the CD.
1. Which type of cancer is most easily seen on a CT? Lung
 2. Where is the hilum located? bronchus
 3. A question about dysplasia
 4. Where are the islets of Langerhans Pancreas
 5. How many main lobes of the liver 4
 - ⑥ Given a CT slice and a list of organs, find which organ is not included in the slice shown.
7. T1 vs T2 MR image. Given an image, choose what the true statement.
8. Extrapolation number. Given the survival curves for two different cell lines, name what is the same for the two. Given a graph showing D_b , D_i , D_e extrapolation number.
9. Given a list of bones, name which one is in the lower leg.

44. Scatter dose at 90 degrees at 1 meter (asked to assume field size = 400cm²), I answered 0.1%

2004 ABR Clinical Part 1, Written.

1. Largest bone in lower leg - tibia, Fibula.

(2) Sagittal MRI labeled with cord, disk, spinous process, ilium. What orientation is this (answer sagittal). Which is incorrectly labeled? The "ilium" label appeared to be pointing to a very bright (ie not bone) lower pelvic structure that I think was the posterior most fluid filled pouch in the floor of the pelvis.

(3) CT through liver / spleen. Which is false - labels were at liver, spleen, this section is at L4-S1 (I chose this). T10-T12 ? L1-2 (female).

4. Location of pancreas (anterior to stomach, between duodenum and spleen (I chose this), posterior

5. Lots of questions on the order of blood circulation through the heart and associated vessels.

6. What structures pass through a hole (worded differently) in the diaphragm. I chose an answer that had esophagus, aorta and vena cava. Other options contained the spine - that's all I recall.

(7) Numerous questions on the effects of radiation at various stages of fetal development.

(8) When does organogenesis begin.

9. Corpus Callosum is in the ...brain, thorax, abdomen, pelvis. Leg.

(10) Irradiation in the first week following conception results in Intruterine death, tekerina in the child, mental retardation, congenital abnormalities

11. Irradiation in late stages of pregnancy results in Intruterine death, leukeemia in the child, mental-retardation, congenital-abnormalities

(12) A patient has reacted to contrast. This would most likely be from barium, iodine, gadolinium, gas bubbles, saline.

(13) Maximum dose to fetus from which exam A. KUB AP B. Lateral Lumbar X-ray, C Cholangiogram, D Barium Enema

(14) The peritoneum is in the A. Abdomen, B. Brain, C. Thorax....

15. Blood drains from the vena cava into ? Right Atrium

and left atrium

① Sub frontal supine Voliquip

Kidney, Bladder, Vagina

② TUP (Intravenous pyelogram)

radiographic procedure to investigate

check of L condition { bowel obstruction gall stones colic stones

liveric stents

gastrointestinal system.

16. Blood leaves left ventricle into what? Aorta

17. Systole Volume = 36cc, Diastole volume = 91cc. What is the ejection fraction of the heart. $\frac{36}{91} \times 100\% = 39\%$ (LVEDV) (91 - 36) cc / 91

18. What is opposite to LPO. (RAO)

19. This may have been in part 1 General. 1 Gy to testes of 20 year old man, result is... A. increased libido, B. decreased libido, C. permanent sterility. D. temporary sterility.

(20) This question may have been in the part 1 general section. Fractionation is used in radiation therapy because of "large shoulder in survival curve" appeared to me to be the only reasonable answer. I don't recall other options.

(21) This question may have been in the part 1 general section. The biological response model extrapolated to low dose is assumed to be "linear non-threshold". I don't think I got the wording of this question right, but the intention is there.

(22) This question may have been in the part 1 general section. Regarding the Oxygen Enhancement Ratio (OER) "Oxygen promotes free radical formation" appeared to be the only reasonable answer. $\frac{D}{A} \text{ dose } \times \frac{OER}{D}$

(23) Regarding fibromyalgia: A. Treated with radiotherapy. B. Causes aches pains stiffness and lethargy. C. causes swelling

24. Virtual Colonoscopy uses: A. PET B. MRI C. CT D. SPECT E. US

25. Autonomic Function is controlled by: I don't remember all the options but the brainstem or something similar was there with all other options in the forebrain. $\frac{D}{A} \text{ brain stem}$

26. The master hormone gland is the: Pituitary

(27) Most stable product of hydrolysis(?) radioysis (?) of water is:
A. OHdot B. Hdot C. H₂O-D. H₂O E. Free Electrons
Dot indicates free radical.
I must admit I still don't know the answer to this I would have thought a question asking about the most unstable product would be more clinically relevant.

28. Sensory cells are in what layer of the eye? A. Sclera B. Choroid C. Retina ...

29. Hypoglycemia can be caused by: A. glucogen B. Insulin C... other answers that didn't appear relevant. $\frac{D}{A} \text{ insulin due to excessive dose}$

30. Calcium levels in the body are controlled by the: A. Parathyroids

glycogen

glucagon

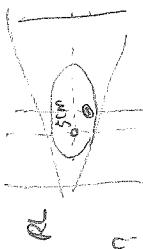
glucagon

glucagon

glucagon

31. Functions of the spleen.
32. The lymphatic system drains into the A Subclavian Veins B. Vena Cava C. Aorta.
33. Male Chromosome - XY
34. Cell Target - DNA
35. Platelets are used for - clotting of blood.
36. Where is the calcaneus found A: foot, BCDE other options far removed from the foot.
37. Brain irradiation to 60Gy (didn't say single or fractionated). What are the late effects?
I said necrosis.
38. Number of cervical vertebrae. 7
39. Function of the liver - produce bile was the only correct answer.
40. Gas exchange in the lungs is by - A diffusion, B. osmosis ...
41. A bundle of nerve fibers is called a - plexus.
42. Ovaries produce which hormone ... E/estrogen appeared to be the only reasonable answer.
43. Radiation is a teratogen because: A. It causes birth defects, B. it causes cancer C. It induces mutations ...
44. The most oxygenated blood can be found in the A. Aorta B. Pulmonary Artery C. Pulmonary Vein. D. Iliac Artery.
45. Blood leaves the left ventricle into the A. Aorta B. Pulmonary Artery C. Right Atrium D Left Atrium.
46. Most food is absorbed in the: A. Stomach B. Duodenum C. Small Intestine D. Colon E. Rectum
47. Blood leaves the Vena Cava to enter the right atrium.
48. Number of lobes of the liver 4
49. Number of lobes in the lungs 2 2 3
50. Artery to the liver L hepatic C
51. Number of temporal lobes in the brain 2

$$6.7 \times \frac{105}{100} = 7.035 \text{ cm}$$



26. Biggest impact on fetal dose according to TG36 (A) Distance to fetus, B. energy C. Blocking, D. Depth below abdomen surface.

(27) Sirho and rho given for lead. Calc MeV/cm then use to calc lead thickness needed to shield 18MeV beam. $\gamma\rho \cdot \rho = \xi \Rightarrow \text{max}/\xi = \text{cm}$

28. HDR 192Ir. Patient treated with time XXX with Activity YYY on Aug 15th. Source replaced with activity ZZZZ on Aug 17th. Treatment time on Aug 22nd is ? No 192Ir half life given. Increase of dose beyond long \rightarrow $\text{dose} = \text{dose}_{\text{initial}} \cdot e^{(t-t_0)/T_{1/2}}$

29. Nothing on TBElectron

30. 10MV through 6cm lung, dose actual vs dose without inhomogeneity. No other data given. Increase of dose beyond long \rightarrow $\text{dose} = \text{dose}_{\text{initial}} \cdot e^{(t-t_0)/T_{1/2}}$

31. A question involving 10mg Ra - simple application of $\Gamma_{XA/d2}$ - but needed to know (if not given) exposure rate const. = 8.25 Rem/mg.hr

(32) Shielding question. 36 in space available for needed 6 TVL (this information was given). Pb TVL given. Concrete TVL given. What is the minimum thickness of Pb needed.

33. How many TVL's in a linac head. $0.1\% \Rightarrow 3 \text{ TVL}$.

34. No MLC questions

35. The only IMRT question: In IMRT the physicist does not define A. Beam Weights B. Field Sizes C. Gantry Angles ...

36. Field size required at midplane is 25cm, maximum can open is 20cm. What is SSD? (separation = 22cm)

37. Slim film taken at 102cm SSD, SFD 140cm. Want to treat at 120cm SSD. What distance to film should be used when cutting blocks. $120 \times \frac{102}{120} = 105 \text{ cm}$.

38. Standard question about the couch kick angle required to make inferior borders parallel on lateral brain fields. For 10x10 field at 10 SSD and measured at 13.7cm \Rightarrow SFD \Rightarrow SFD = 16.5 cm

39. Breast Tangent pair. Field widths at 100 SSD = 10.5 cm DAO has gantry angle 45 degrees. What gantry angle does RPO have such that posterior borders will be parallel. 40. I'm vague on this one but I'll give it to you anyway. The question went like The simulator couch wouldn't go low enough, so the film was taken at X SSD, separation 25 cm, distance to film = 140 cm, simulator film needs to be placed at what distance to cut blocks.

$$\text{mag} = \frac{110}{13.75} \Rightarrow \text{SFD} = \frac{140}{13.75} \times (13.75 + 2.5) \quad \gamma + \beta = 90 - \beta$$

$$\text{SAD} = \frac{140}{13.75} \quad \gamma = 90 - 2\beta$$

$$\text{or } \text{SSD} = \frac{140}{X} \Rightarrow \text{SFD} = \frac{(140}{X} \cdot 132)$$

$$\text{SAD} = \frac{140}{13.75} \quad \gamma = 90 + 2\beta$$

$$\beta = \arctan \left(\frac{F}{2 \times 100} \right) = \arctan \left(\frac{10.5}{200} \right) \quad \gamma = 28.9^\circ \Rightarrow 30^\circ \text{ or}$$

(41) No diagram with this one making it tough. Patient on simulator couch with isocenter 5cm right of midline. Wire placed on midline (didn't say A or P. R. Lat film taken. Measured cord depth of 6.7cm, but therapist forgot to reset isocenter to midline. What is the true cord depth. If you think this is confusing, then I agree. Basically I think the depth was measured assuming isocenter at midline, then question was asking what is the true depth.

42. PDD for wedge increases over open field due to: A. Photon interactions in the wedge B,C,D,E,... other options that didn't look right. beam hardening \Rightarrow high Energy

43. Beam steering vs gantry angle in a linac. Signals to steer originate from ion chamber ... various other options. monitor dose rate & integral dose

44. Considering a dual ion chamber scanning water tank, an error in the PDD (a shift up or down - I don't recall which) is not due to A. incorrect zero - is set above water level B. RF interference C. water / air temperature differential D. Stepper motors not calibrated correctly.

45. No electron Arc questions, no gamma knife questions, no SRS questions.

46. Electron cutout changed from 6x6 to 4x4. What doesn't change? A. Bremsstrahlung B. Chopper jaws Output Factor, C. Depth of 80%, D. Surface Dose.

47. 150 ionization depth of an electron beam is 5.1 cm. The energy of the beam is

48. Saturation in an ionization chamber refers to ... A voltage high enough to prevent recombination ... other options that were not correct.

49. A survey points a linac beam at a primary wall and measures 2mR/hr. Is this OK? There were various options in the answers, but this was the point of the question.

(50) An ion chamber is used to perform a survey. You also need all of the following except: A. Dose rate of linac B. Sufficient buildup around the survey meter C... other options that looked to me like they were required.

51. SAR for this radial section: Diagram given, table of SARs given.

52. Classic electron ISL calculation straight from Kahn, ie calculate the effective SSD, given energy, field size, dmax (2cm), given slope of $(I_0/I_g)^{1/2} = 0.0111$. Note with zero gap $\frac{I_0}{I_g} = \left(\frac{f}{f+dm} \right)^{1/2}$

$f = 90^\circ - \beta$

$\beta = 360^\circ - [90^\circ - \beta] + \delta]$

$= 360^\circ - [90^\circ - \beta] + (0^\circ - \beta)$

$= 180^\circ + \beta$

$\beta = 40^\circ - \beta$

$\beta = 360^\circ - [90^\circ - \beta] + \delta]$

$= 360^\circ - [90^\circ - \beta] + (0^\circ - \beta)$

$= 180^\circ + \beta$

2004 Part 1 Writtens

The Physics Section of Part I consisted of 75 multiple choice questions in a three hour period. Each question was followed by five choices (A through E); there were no true/false questions. There was no differentiation between "easy type" and "hard type" questions as there has been in past ABR sample questions--there were simply 75 questions in three hours, one after another.

Several questions were dedicated to computer terminology and data management... Examples follow.

① A CT scan with a 512x512 matrix and 300 images is compressed at 1.5:1 compression. The transfer rate is $\sim 1.7 \text{ Mbit/sec}$, how many minutes for the transfer? (You'd have to know the standard bit depth of a CT image).

$$1.1 \text{ min} \rightarrow 5.8 \text{ min}$$

2. A terabyte is equivalent to:

- a. 10E4
- b. 10E5
- c. 10E6
- d. 10E7

3. What category of storage is an optical disk that cannot be overwritten? WORM (Write Once, Read Many)

4. What is the name for a computer program that translates programming code into computer instructions?

- a. Operating system
- b. compiler
- c. CPU

Several questions were dedicated to counting statistics and uncertainty, such as

5. If a sample has 1600 total counts in 4 minutes and the background has 900 total counts in 3 minutes, the activity of the sample is 100 ± 1 cpm.

6. How many counts do you have to take of a sample to be 95% sure that you fall within 4% of your first count rate?

$$N = 10 \quad N \rightarrow 14 \text{ cpm}$$

There was one circuit:

Q Given a diagram of a circuit consisting of a battery, a resistor, and then a resistor and an inductor in series. Values for all of the components were given. The question was: what is the current through the resistor that is in parallel with the inductor at time $\rightarrow \infty$?

There were several questions relating to basic functions, and since it was a multiple choice test, it was pretty straightforward, such as:



8. What value of t gives this function its maximum value? $Y = 2t - e^t$

There were a few questions on ultrasound, such as: $e^{-\mu Y} \propto t + \mu_1$

Q. Ultrasound transducers transmit and receive pulses using what effect? \downarrow \uparrow \downarrow \uparrow

10. US assumes 1540 m/s, but for fat, it's really 1460 m/s. An ultrasound image shows fat as being 2 cm thick. How thick is the fat really? 1.9 cm

There were several questions involving types of decay or interactions, such as:

11. C decays to D* by β^+ . D* cannot decay to the ground state by gamma emission. How can it decay?

- a. neutrino
- b. electron capture
- c. Auger electron
- d. Internal conversion

12. A 9.5 MeV photon passes by the nucleus of a lead atom. How many pair productions can take place? 1

There were a few basic isotope decay questions where you had to calculate an activity:

13. given a physical and biological half life, what remains after some time

14. given the parent half life and the much smaller daughter half life, what is the activity of the daughter in a long time?

A large number of questions related to HVL's and exponential attenuation, such as

15. given mass fractions of two materials and their attenuation coefficients, what is the combined attenuation in a compound?

16. how many HVLs is 6 TVLs? 0

17. If a patient is 8 HVLs thick, what's the ratio of entrance exposure to exposure at midpoint? $1/8$

18. Given an isotope that emits a high energy photon and a low energy photon. The low energy photon is emitted 4 times as frequently. Attenuation coefficients are given. What's the ratio of low to high isotopes after traveling through 20 cm of water?

19. Given attenuation coefficients for lead and aluminum, how much aluminum is equivalent to x mm lead?

There were several workload-type calculations, such as:

20. A secretary's desk is behind a wall behind a chest bucky. The mR/hr is given for a 30 mA, 1 sec examination at 120 kVp. The weekly workload is 300 mA*min/week. What's the overall exposure rate to the secretary in mR/wk?

$$30 \text{ mA} \Leftrightarrow \text{mR/hr} \Rightarrow \text{mR/mAs}$$

There were several dosimeter-type questions, such as:

21. A chamber that has reached saturation is:

~~ion chamber~~

22. A pressurized chamber reads 90% of the incident radiation. The pressure is decreased by a factor of 10. What percent of the incident ionization does the chamber then read? $\rightarrow e^{-0.1 \text{ ut}}$

There was one dead-time question:

23. Given a measured count rate of 100,000 cps and a dead time of 2 μs , what's the true count rate on a non-paralyzable system?

$$N = \frac{N}{1 + T \cdot N_{\text{dead}}}$$

$$\frac{100,000}{1 - 0.2} =$$

And then there were a smattering of basic physics questions, but they were simple calcs, such as:

$$\frac{1}{2} I \omega^2$$

24. What's the kinetic energy of a rotating anode with I and rotational speed given?

25. What's the decrease in density of a brick that's heated and expands 0.2% on each side? $\rho_1 / \rho_2 = \rho_2 / \rho_1 = 1.006 \rightarrow \rho_2 / \rho_1 = 0.994 \quad 0.6\%$

26. If $V(r) = -130 \log(r)$ in a cylindrical chamber, what's the electric field at $r = 0.5 \text{ cm}$? $E = \frac{V_0}{r} = \frac{130}{0.5} = 260 \text{ V/cm}$

And a few imaging physics questions, such as:

$$OD = \frac{OB \cdot OB}{OB + OF}$$

27. Given a list of exposures (mR) and film O.D.'s, what's the film speed?

$$\gamma = \frac{OB \cdot OB}{OB + OF}$$

28. Given the ODI hits a 10mm thick plastic tray of $n=1.5$ at 35 degrees, by how much is the ODI shifted at the bottom of the tray? $\Delta = \frac{C}{V} \cdot \delta_{\text{mm}}$

One item of note is that you didn't have to know any physical constants off the top of your head; they were all given to you in the problems if you needed them at all. Also, the answers given didn't seem to be designed to trick you; e.g. if you were calculating the rotating anode kinetic energy ($KE = \frac{1}{2} I \omega^2$) and you forgot to square the ω , that result was not close to a possible answer.

The Clinical Portion of Part I consisted of 50 questions in 1 hour. Most people were done in less than half of that time. I was hoping for more overlap from past exams than there was. Again, each question had 5 possible answers, no T/F.

Radiation biology/health physics had many questions, such as:

- ① Organogenesis occurs in 2 to 15 weeks.
- ② Irradiation of 1 Gy during preimplantation most likely leads to deafness.
- ③ The background dose excluding radon at sea level is 1-10 mSv/yr.
- ④ Dose risk estimates are based on the linear model (linear, no threshold; linear-quadratic, threshold; etc)
- ⑤ An axial CT slice containing the liver and spleen, and you were asked to pick what wasn't accurate (e.g. it's at the level of L4).
- ⑥ A sagittal MRI that asked what's wrong?
- ⑦ What's a plexus?
- ⑧ BEIR depends on: total dose, dose rate, fraction size...
- ⑨ The following things pierce the diaphragm: spinal cord, aorta, esophagus, vagus, cava, trachea in various combinations
10. Where does filtered lymph reenter the bloodstream? lymph
11. What produces estrogen? ovary
- ⑫ What is the overall controller in the endocrine system? pituitary, thyroid, parathyroid, hypothalamus
13. How many temporal lobes are there? (0, 1, 2, 3)
- ⑭ What is teratogenesis?
- ⑮ Which diagnostic procedure provides the highest dose to a fetus? (Lateral spine x-ray, barium enema, upper GI) barium enema
- ⑯ What is fibromyosis associated with? muscle
- ⑰ What is tetraparesis? quadriplegia

There were several workload-type calculations, such as:

26. A secretary's desk is behind a wall behind a chest bucky. The mR/hr is given for a 30 mA 1 sec examination at 120 kVp. The weekly workload is 300 mA * min/wk. What's the overall exposure rate to the secretary in mR/mwk?

There were several dosimeter-type questions, such as:

27. A chamber that has reached saturation is:

22. A pressurized chamber reads 90% of the incident radiation. The pressure is decreased by a factor of 10. What percent of the incident ionization does the chamber then read?

- There was one dead-time question:

23. Given a measured count rate of 100,000 cps and a dead time of 2 μ s, what's the true count rate on a non-paralyzable system?

- A. 100,000
B. 105,000
C. 110,000
D. 130,000
E. 150,000

- And then there were a smattering of basic physics questions, but they were simple calcs, such as:

24. What's the kinetic energy of a rotating anode with I and rotational speed given?

$$\frac{1}{2} I \omega^2$$

25. What's the decrease in density of a brick that's heated and expands 0.2% on each side?

$$\rho_1 V_1 = \omega_c - \rho_2 V_2 \\ \rho_1 / \rho_2 = 1.006 \rightarrow \rho_2 / \rho_1 = 0.994 \quad 0.6\%$$

26. If $V(r) = -130 \log(r)$ in a cylindrical chamber, what's the electric field at $r = 0.5$ cm?

$$\frac{V(0)}{r} = -260$$

And a few imaging physics questions, such as:

27. Given a list of exposures (mR) and film O.D.'s, what's the film speed?

$$OD = 1 \quad r = \frac{0.07 \cdot 0.07}{1} = 0.0049$$

28. Given the ODI hits a 10mm thick plastic tray of n=1.5 at 35 degrees, by how much is the ODI shifted at the bottom of the tray?

$$OD = \frac{1}{\sqrt{n}} \quad \Delta = 8 \text{ mm}$$

- One item of note is that you didn't have to know any physical constants off the top of your head; they were all given to you in the problems if you needed them at all. Also, the answers given didn't seem to be designed to trick you; e.g., if you were calculating the rotating anode kinetic energy ($KE = \frac{1}{2} I \omega^2$) and you forgot to square the ω , that result was not close to a possible answer.

2. Clinical Portion

The Clinical Portion of Part I consisted of 50 questions in 1 hour. Most people were done in less than half of that time. I was hoping for more overlap from past exams than there was. Again, each question had 5 possible answers, no T/F.

Radiation biology/health physics had many questions, such as:

- ① Organogenesis occurs in 2 to 15 weeks.

- ② Irradiation of 1 Gy during preimplantation most likely leads to degeneration (0.3% m/sv / 1.4x10^-4 Sv/hr. ($1.8 \times 10^{-3} \text{ mR/h}$))

- ③ The background dose excluding radon at sea level is ~10 mSv/yr.

- ④ Dose risk estimates are based on the linear-quadratic dose effects model (linear, no threshold; linear-quadratic; threshold; etc)

- ⑤ What's a plexus?

- ⑥ A sagittal MRI that asked what's wrong.

- ⑦ What's a BEER?

- ⑧ BEER depends on: total dose, dose rate, fraction size...

- ⑨ The following things pierce the diaphragm: spinal cord, aorta, esophagus, vagus/cava, trachea in various combinations

- ⑩ Where does filtered lymph reenter the bloodstream? sub lymph

- ⑪ What produces estrogen? ovary

- ⑫ What is the overall controller in the endocrine system? pituitary, thyroid, parathyroid, hypothalamus

- ⑬ How many temporal lobes are there? (0, 1, 2, 3)

- ⑭ What is teratogenesis?

- ⑮ Which diagnostic procedure provides the highest dose to a fetus? (Lateral spine x-ray, barium scan, upper GI) barium scan

- ⑯ What is fibromyosis associated with? muscle

24754

31. Functions of the spleen.
32. The lymphatic system drains into the A. Subclavian Vein ✓ B. Vena Cava C. Aorta.
33. Male Chromosome – XY
34. Cell Target – DNA
35. Platelets are used for – clotting of blood.
36. Where is the calcaneus found A. foot, BCDE other options far removed from the foot.
37. Brain irradiation to 60Gy (didn't say single or fractionated). What are the late effects? I said necrosis. ✓
38. Number of cervical vertebrae. 7
39. Function of the liver – produce bile was the only correct answer.
40. Gas exchange in the lungs is by – A. diffusion, B. osmosis
41. A bundle of nerve fibers is called a – plexus.
42. Ovaries produce which hormone ... E. estrogen appeared to be the only reasonable answer.
43. Radiation is a teratogen because: A. It causes birth defects, B. it causes cancer C. It induces mutations ...
44. The most oxygenated blood can be found in the A. Aorta B. Pulmonary Artery C. Pulmonary Vein, D. Iliac Artery.
45. Blood leaves the left ventricle into the: A. Aorta B. Pulmonary Artery C. Right Atrium D. Left Atrium.
46. Most food is absorbed in the: A. Stomach B. Duodenum ✓ C. Small Intestine D. Colon E. Rectum
47. Blood leaves the Vena Cava to enter the right atrium.
48. Number of lobes of the liver 4
49. Number of lobes in the lungs < 2 R 3
50. Artery to the liver krtotic c
51. Number of temporal lobes in the brain ✓

52. OER with dose rate or LET (I can't recall which) increases / decreases.

53. Radiation therapy works because of Various statements about the shape of the dose response curve. A statement about a "wide shoulder" looked best to me. Other statements concerned things such as synchronization / rephasing of the cell cycle.

44. Scatter dose at 90 degrees at 1 meter (asked to assume field size = 400cm²). I answered 0.1%.
16. Blood leaves left ventricle into what? Aorta
17. Systole Volume = 36cc, Diastole volume = 91cc. What is the ejection fraction of the heart: $\frac{36}{91} \times 100\%$ (LVEF) (91 - 36) cc / 91
18. What is opposite to LPO. (RAO)
19. This may have been in part 1 General. 1 Gy to testes of 20 year old man, result is... A. increased libido, B. decreased libido, C. permanent sterility. ~~D. temporary sterility.~~
20. This question may have been in the part 1 general section. Fractionation is used in radiation therapy because of.... "large shoulder in survival curve" appeared to me to be the only reasonable answer. I don't recall other options.
21. This question may have been in the part 1 general section. The biological response model extrapolated to low dose is assumed to be "linear non-threshold". I don't think I got the wording of this question right, but the intention is there.
22. This question may have been in the part 1 general section. Regarding the Oxygen Enhancement Ratio (OER) "Oxygen propotes free radical formation" appeared to be the only reasonable answer.
23. Regarding fibromyalgia: A. Treated with radiotherapy ~~B. Causes aches/pains/stiffness and lethargy C. Causes swelling ...~~
24. Virtual Colonoscopy uses: A. PET B. MRI ~~C. CT D. SPECT E. US~~
25. Autonomic Function is controlled by: I don't remember all the options but the brainstem or something similar was there with all other options in the forebrain. ~~A. Hypothalamus B. Pituitary C. Hypothalamus and Pituitary D. Hypothalamus and Pituitary~~
26. The master hormone gland is the: Pituitary
27. Most stable product of hydrolysis(?) radioysis (?) of water is:
A. OHdot B. Hdot C. H₂O₂ D. H₂O E. Free Electrons
Dot indicates free radical.
- I must admit I still don't know the answer to this. I would have thought a question asking about the most unstable product would be more clinically relevant.
28. Sensory cells are in what layer of the eye? A. Sclera B. Choroid C. Retina ...
29. Hypoglycemia can be caused by: A. glucogen ~~B. insulin C. ... other answers that didn't appear relevant.~~ ~~D. insulin due to excessive dose~~
30. Calcium levels in the body are controlled by the: A. Parathyroids
31. Maximum dose to fetus from which exam
A. KUB AP B. Lateral Lumbar X-ray, C Cholangiogram, D Barium Enema
~~E. MRI~~

32. The peritoneum is in the A. Abdomen, B. Brain, C. Thorax.

33. Maximum dose to fetus from which exam
A. KUB AP B. Lateral Lumbar X-ray, C Cholangiogram, D Barium Enema
~~E. MRI~~

34. Blood drains from the vena cava into ? Right Atrium

35. Supine radiography ~~② X-ray exam larger bile ducts within liver~~
and out side

36. ~~intral~~ supine radiography ~~② X-ray exam larger bile ducts within liver~~
kidney, Bladder, Ureters

37. TUP (Intravenous pyelogram) ~~② Radiographic procedure to investigate pathology of kidney, Bladder, urinary system.~~

38. check gI condition ~~gall stones~~
kidney stones
uretic stents

16. Electron accelerated through 4MV, what velocity? Fast solution again uses $\gamma \rightarrow 0$. 994 c

17. Voltage as a function of radius $V=130\log(r)$. Electric Field strength V/cm at $r=0.5cm$?

18. Unit vectors $\hat{j} \times (\hat{i} \times \hat{j})$ (ie j cross i) = - k .

19. Length of $l\hat{i} + l\hat{j} + l\hat{k}$ $\sqrt{3l^2}$

20. Neutron of velocity XXXX hits and is captured by ^{59}Co nucleus. Before ^{60}Co decays, what is the velocity of the ^{60}Co nucleus (I applied simple cons of momentum)

$\int \frac{m \cdot \omega}{M_C \cdot b^2}$

21. Photons of two different energies of initial number ratio 4 to 1 pass through 20cm of water. μ given for both energies. What is the number ratio of photons after passing through the 20cm of water.

$$4e^{-\mu L} / e^{-\mu L} = 4e^{-\mu L}$$

22. Find the μ of a mixture of materials, weight fractions given. μ/p of components given, p of mixture given. Solution: add μ/p by weight fraction then multiply by p of mixture.

23. $\Gamma = 1.5$ (units) for an isotope with 100% efficiency, 1 MeV per decay. What is Γ (same units) for an isotope with 80% efficiency, 2 photons per decay, each 0.75 MeV.

$$\Gamma = \frac{1}{2} \cdot \frac{8}{3} \cdot \sum_i \left(\frac{1}{2} \cdot i \cdot \frac{1}{2} \cdot i \cdot \frac{1}{2} \cdot i \right) \cdot 1.5 \rightarrow 2.25$$

24. Ultrasound assumes 1540 m/s (given). A layer of fat 2cm thick has actual velocity 1460m/s (given). The ultrasound will measure the fat layer as ??? cm thick?

A. 1.8 B. 1.9 C. 2.0 D. 2.1 E. 2.2

25. An ODI light takes a path at 35 degrees to a linac beam axis. A 10mm thick block tray is inserted into the path of the ODI perpendicular to the linac beam axis. (no diagram given). What is the lateral shift in the ODI light. The refractive index of the block tray is 1.5.

26. An ion chamber survey meter has 90% efficiency at 10 atmospheres. The pressure in the chamber drops to 1 atmosphere. What is the new efficiency? Answers started at 21% and went up (ie 9% was not there). If you consider a new linear attenuation coefficient of $1/9^{\text{th}}$ the original I ended with 21%

27. No CT in parts 1 or 2 (other than anatomy in clinical section)

28. Radiofrequency used in 1 Tesla MRI is... (not given 42.6 MHz/Tesla gyromagnetic ratio) 42.6 MHz was a possible answer.

29. No α/β radiobiology questions (in 1 General or clinical)

30. Do is the ??? on a cell survival curve (question was worded so that the shoulder was not to be considered) A. 37% cell survival, B... other options that didn't look right. This question may have been in the clinical section.

31. Function $y=2x-e^x$. Find the position of the maximum. $\int_{\ln 2}^{\infty}$

32. $0.1\text{En} \int_0^{\infty} (\text{En}-E)dE$. Evaluate the definite integral in terms of En. $\partial, \psi, \phi, f, E, m$

33. Calculate the Kinetic energy in a rotating disk given the moment of inertia and the angular velocity in both revolutions/sec and radians/sec. $K_E = \frac{1}{2} I \omega^2$

34. A Petabyte is $2^{30} \times 10^{12}$ bytes
A. 0.98 B. 1.02 C. 1.05 D. 1.07 E. 1.10

35. A number (given) of CT images of size 512x512 are compressed with 2.5:1 compression. How long to transfer these images over a T1 line (T1 line bandwidth of XXX Mbits/sec was given). No information was given about how many grey levels or bits or bytes per pixel. I assumed 8 bits (1 byte) per pixel and got an answer that was available.

36. A number of detector area / distance from source / geometric efficiency problems like others in previous years. Some requiring steradian calculation.

37. Something about specificity is associated with One of the answers was "ROC". $S_{ROC} = \frac{TP}{TP+FN}$
Various other statistical terms were provided but didn't appear to have anything to do with sensitivity / specificity. I don't recall anymore, but gave this anyway.

38. A ball is thrown vertically. Question asked for time or height to top – I don't recall. Initial velocity given, but not gravitational acceleration. Velocity given in km/hour.

39. A circuit diagram (diagram given) with a battery in series with a switch, then resistor A, then resistor B, then back to battery. Inductor L is in parallel with resistor B only. A long time after the switch is thrown, how much current goes through resistor B? I think the answer is zero as it all goes through the inductor – this was an option.

40. An electrical meter has an internal 5k ohm resistor and registers full scale at 50 micro A. How many meg ohm to insert in series to turn meter into a XXXXX range voltmeter? The answers were all tenths of a meg ohm apart so you could ignore the effect of the 5k ohm internal resistor and just apply $V=IR$.

41. An electrical supply line loading question. Some large piece of electrical equipment has a peak power output of XXXXX kW. If this is maintained, but voltage changed from 480V to 240V, by what ratio will supply line losses change. I think the answer is an increase in losses by a factor of 4.

42. What is unerasable data storage called – A. RAM, B. WORM.

43. Typical shielding in a diagnostic x-ray facility is Xmm of lead... A. 1 mm B. 5mm ...

2004 ABR Written timing considerations. I put a lot of effort not just into learning the material but into learning fast ways to solve problems. It's not good enough if you know how to solve a problem but it takes twice the allocated time per question. Here is how I went with regard to time. I simply divided up the allocated time evenly on a per point basis:

Part 1 (General) I was 15-20 minutes ahead at the end of the first 50 one point questions, then picked up at least this amount again during the 25 three pointers. This meant I had something like 45 minutes for review of my flagged questions after completing a first pass – this was much faster than I expected.

Part 1 (Clinical) Similar to candidates from previous years, I finished with plenty of time to spare and actually reviewed every single question.

Part 2 (Therapy) Again I was 15-20 minutes ahead at the end of the first 50 one pointers, but then lost all of this during the 25 three pointers. Some three pointers were quite fast, but quite a number of them were very time consuming eg the TG51 question (number 2 below) has many small calculations within it. I used all but a few minutes to get the exam done, with only a few flagged questions reviewed at the end.

Part 1 (Clinical) Similar to candidates from previous years, I finished with plenty of time to spare and actually reviewed every single question.

This recollection of questions should provide a tremendous help – just like previous candidates recollections did for me. Good Luck!

2004 ABR General Part 1, Written.

1. Two counts of same source, what counts to give 95% chance that the two counts will measure within 4%. (I did 0.04 = $2\sigma/\text{sigma/mu}$) $N = 25 \times \infty$

2. Classic Curve, Co₆₀, dead time question.

$$R_t = R_0 / (1 - R_0 \cdot \tau)$$

3. 1600 counts over 4 mins (meas), background 900 counts over 3 mins (measured). What is the standard deviation in net count rate (cpm)?

4. XXXX n/cm²/sec activates YYYY atoms of 59Co per unit time. What is the max activity of 60Co (C) that can be achieved. (I didn't use the n/cm²/sec)

$$2 \cdot \rho \cdot N_A \cdot t = C \cdot N_A \cdot t$$

5. Chromium neutron activation. Half-life given. When is 80% of max activity established.

6. Effective weight if half body (ie below diaphragm) irradiated. Weights for various organs of the body given. Had to know things like lung, breast, thyroid and esophagus are above diaphragm so could remove them from the total.

7. Had an A to B to C decay. (like 99Mo – 99mTc – 99Tc but not told this). A has 10hr half life, B has 1 hour, C stable. If only A to start, what is ratio B/A at 5 hours. Answers 1.0, 0.6, 0.3...

$$B/A = e^{-t/T_A}$$

8. In an isotope where gamma emission is forbidden, what else is an alternative – interpal conversion.

9. Decay emits only neutrinos and characteristic x-rays. This is? Electron Capture.

10. P31 1.71MeV gamma ray (given). Best shielding material is

A. 1mm Acrylic, B. 1cm Acrylic, C, D, E... Pb of various thicknesses

11. Max dose patient in hospital near "radioactive" patient can receive is $\sqrt{\text{mSv}} \cdot B$. $\sqrt{\text{mSv}} \cdot C$...higher doses.

12. Physicist does 50 brachy patients per year. Max dose allowed (per NCRP 116) torring badge per patient is?

$$50 \text{ patients} / 10 \text{ years} = 5 \text{ patients/year} = 1 \text{ patient/2 months}$$

13. KM auger electron energy given KLM energies (need to know Aug. e emitted from shell where transitioning electron originates)

$$E_{\text{e}} = \frac{1}{2} m_e V^2$$

14. Electron Anode to cathode time? Given voltage and distance. No mass of electron given. A fast solution involves calculating the final $\gamma = 1/(1 - V_f^2/c^2)^{1/2}$. Solve for V_f final, assume $V_{\text{average}} = V_f/2$ (OK if only few 100 keV), then get time from distance.

15. Electron 0.9c, what is the total mass / energy in MeV. Given $m_0 = 0.51 \text{ MeV}$.

$$E = \gamma m_0 c^2 = \sqrt{1 - \beta^2} m_0 c^2 = \sqrt{1 - \beta^2} \cdot 0.51 \cdot 17 \text{ MeV}$$

✓ 43

17. Stats questions. Poisson.
18. Calc. Kerma. They give both energy transfer coeff and attenuation coeff.
19. Calc effective atten Coeff for a given compound
20. Calc the effective Z for a compound
21. Calc the dose to the gas in a dosimeter knowing the energy absorbed in the gas, the volume of the gas and the density of the gas
22. Given a graph of velocity of an object vs. time, calculate the distance that the object traveled over the time period shown in the graph.
23. Given an equation for the potential in x, y, and z, calculate the components of the electric field.
24. Calculate a temperature and pressure correction for an ion chamber given the temperature and pressure at the time of measurement.
25. What is the angle between two vectors u and v if the resultant of the two vectors is perpendicular to u and has a magnitude that is half of v?
- Clinical Section:
- I thought this was really easy especially after going over the CD. I'll try to remember the only question that I don't remember from the CD.
1. Which type of cancer is most easily seen on a CT? Lung
 2. Where is the hilum located?
 3. A question about dysplasia neoplasia
 4. Where are the islets of Langerhans Pancreas
 5. How many main lobes of the liver 4
- Given a CT slice and a list of organs, find which organ is not included in the slice shown.
7. T1 vs T2 MR image. Given an image, choose what the true statement.
8. Extrapolation number. Given the survival curves for two different cell lines, name what is the same for the two. Given a graph showing D_0 , D_1 , D_t , extrapolation number.
9. Given a list of bones, name which one is in the lower leg.

29. You have a 6×6 electron cone with a 4×4 insert, what doesn't change? (R practical) $D_{\text{refr}} = D_{\text{refr}}$

30. Given an isotope with a known half-life, how long does it take to give 95% dose. $D = D_0 \cdot e^{-kt} = D_0 \cdot e^{-(1/\tau_{1/2})t} = D_0 (1 - e^{-t/\tau_{1/2}})$

31. You want to limit a total dose at 1 meter from a patient that has brachytherapy implants to 500 mRem, what is the maximum initial dose rate? I think the was Iodine 125.

$D_{\text{avg}} = 500 \text{ mRem}$

32. How often do you have to calibrate the barometer according to TG 40?

33. TG 40, what % is the flatness of the beam should be? 2% \rightarrow $\rho_{\text{air}} = \rho_{\text{air}}(1 - 0.00015 \times 50) = 0.99985 \rho_{\text{air}}$

34. You are 50 meter above the airport, what % change do you expect to see in pressure? 0.6%

35. Given an AP and a Lat film with two points identified, find the distance between them. $(X_1 - X_2)^2 + (Y_1 - Y_2)^2$ or length pro

Part 1 of the ABR exam 2003

Physics Section:

30. Given an isotope with a known half-life, how long does it take to give 95% of total dose.

$$D = D_0 \cdot T_{1/2} \cdot \left(1 - e^{-\frac{\ln 2}{T_{1/2}} t}\right) = D_0 \cdot (1 - e^{-\frac{\ln 2}{T_{1/2}} t})$$

$$0.95 = \left(1 - e^{-\frac{\ln 2}{T_{1/2}} t}\right) \Rightarrow 0.95 = \left(1 - e^{-\frac{\ln 2}{7200} t}\right)$$

The CD is great and I thought it was helpful and relevant to what was on the test. Here are some specific questions I remember from the practice section.

$$D = \dot{Q} \cdot T_{\text{air}} (1 - e^{-\frac{t}{T_{\text{air}}}}) = 0.144 T_{\text{air}} \left(1 - e^{-\frac{1000 t}{T_{\text{air}}}}\right) \Rightarrow 0.95 = \left(1 - e^{-\frac{1000 t}{T_{\text{air}}}}\right)$$

31. You want to limit a total dose at 1 meter from a patient that has brachytherapy implants to 500 mRem, what is the maximum initial dose rate? I think the isotope was Iodine 125.

32. How often do you have to calibrate the barometer according to TG 40? 3 month

33. TG 40, what % is the flatness of the beam should be? 2% → photon.

34. You are 50 meter above the airport, what % change do you expect to see in pressure? -6%

35. Given an AP and a Lat film with two points identified, find the distance between $\rho = \rho_b$, $\rho = \rho_{max}$, $\rho = \rho_{min}$.

then, $\boxed{(X_1-X_2)^2 + (Y_1-Y_2)^2 + (Z_1-Z_2)^2}$ or length projections

8. How long will it take to transfer a set of images if the transfer rate is X bits/s and the images are a 1024 matrix with 8 bits/pixel with a transmission overhead of 2%?

9. For a conventional CT, images are 512×512 with 256 shades of grey. How many can

10 Given you have a solution which is 60% NaCl and contains 15 g NaCl what volume would be stored on a 5.0 GB storage device without compression?

Q. Given you have a solution which is 0.9% NaCl and contains 45 grams of NaCl. How many grams of NaCl do you have to add to make a 75% NaCl solution?

11. Given a ball shot at a velocity of 2000 km/hr at a 45 degree angle. At what distance will the ball land? Ignore drag forces.

12. Which laser would not be used for fiber optic communication? HeNe, YAG, Q-switch

13. Given Isotope A and B. Isotope B has two times the activity of A and emits a particle with twice the energy. The dose from B will be X times that from A over the same

time

14. The entrance dose is 4 Gy and the exit dose is 25mGy on a patient that is 22 cm thick. What is the dose at the middle of the patient? **100 mGy**

15.

J

Neutron activation.

16. Neutron loses 0.5 of energy per collision. How many collisions to lose x energy?

$$11. \quad v \propto \cos \theta. \quad v \propto \sin \theta \quad v_0 / \sqrt{2} = gt \Rightarrow t = \frac{v_0}{g}$$

linear momentum for particle:

$$L = \mathbf{r} \times \mathbf{p}$$

linear momentum

$$= mv^r \cdot \hat{s} \cdot \Omega$$

for circular: $L = mv^r$

for angular momentum for object:

$$L = I \times \omega$$

General Physics:

A ball is thrown into the air with a given velocity. When will it reach its peak?

A question about the angular momentum.

A weight is sitting on a beam that is supported by two columns. Given the location of the

weight on the beam, calculate the force on each beam.

? Electron travels from the cathode to anode (Voltage and distance was given). How long does it take for the electron to travel this distance.

A question about the angular momentum.

Given the initial activity and the activity at a time t in a biological system (e.g. the effective half-life) and the physics half-life, calculate the biological half-life.

Part (40 %) of the activity is lost with a effective half-life of τ_x . The other part (60%) is cleared with a different effective half life, calculate the activity at a time t.

Two isotopes have a given count rate in window A and B respectively. For a mixture calculate the activity of isotope B.

A ultrasound beam impinges at an angle θ onto an interface. What is the angle of the reflected beam (desities were given)

A question about the pulse repetition frequency of a ultrasound transducer. The focal depth was given.

At a given frequency a ultrasound beam is attenuated by 20 dB. If the frequency changes from 2 to 4 MHz, what is the new attenuation.

RC circuits.

focal depth Compton scattering. Angle and initial energy are given. Calculate energy of scattered photon.

Beta plus decay, amus are given. Calculate the max energy of the positron.

The hex equivalent to a binomial number.

Calculation of accumulated dose $1.44 \cdot A^0 \cdot T^{1/2}$

What is the accumulated dose of an I-125 implant after 60 days.

The hex equivalent to a binomial number.

$A = A_0 \cdot e^{-\mu t}$

$A = \int_0^\infty A(t) dt$

$= 1.44 T^{1/2} A_0$

$$T_{1/2} = \frac{\ln 2}{\mu}$$

$$\frac{T_0}{T_{1/2}}$$

ABR 2001 Exams
As general strategy I would recommend looking into old RAPHEX exams. Do as many as possible. I also found that there were several questions posted on the ABR web site that looked very similar to those listed in the exam.

General Exam

For this section, the key is to study Hendie's book: Medical Imaging Physics

- If the efficiency of a 10 atm GM counter is 50% and drops to 1 atm, what is the new efficiency
- Detector has count rate of X
- Neutron activation, what is the activity of a ^{59}Co source irradiated in a neutron flux with an activity of X
- Radiation protection question
- Statistics question
- Voltage question similar to demo question on web site. What is the electric field at 0.5 cm from electrode.
- Survival fraction given D_0 , n , what is D_q
- Calculate speed of film, given HD curve

Radiation Oncology

Kahn's book: The physics of radiation therapy is the key reference for this exam.

- What is the dose at a point X m from source
- Match the energy with isotope
- Numerous questions regarding shielding for brachytherapy
- Given the basic calibration data such as charge, N_a, Pion, Propl, etc what is the dose / MU value for the ion chamber. This equation required you to basically plug in the TG-21 values and compare your answer to the five choices.
- MU calculation involving isocentric treatment plan with SAD = 100 cm. Required to look up data from several tables and determine what the correct MU is.
- MU calculation involving extended SSD calculation. This required knowledge of Kahn's method for extended SSD treatments. The SSD was 110 cm.
- Shielding calculation
- Tangential breast treatment question where you were required to determine the angle between the CAX of the two tangent fields.
- Single TG - 40 question
- Several questions regarding Federal regulations etc.

CT

\Rightarrow better axial resolution \Rightarrow better axial resolution

\Rightarrow less dispersion (θ)

\Rightarrow narrower beam width \Rightarrow sharper

\Rightarrow \downarrow imaging depth (L)

\Rightarrow \downarrow uptake is not rapid in comparison with TP

\Rightarrow tell you $\frac{\text{uptake half life}}{\text{TP}}$

\Rightarrow $A_u = 1.44 A_0 T_c (T_c/T_{1/2})$ biological uptake effective uptake effective half life

\Rightarrow $A_u = \frac{T_c T_p}{T_{1/2} T_p}$

Calculate dose at cord given dose at prescription depth
 Calculate total dose given several beams which traverse several cm of lung
 % change in PDD for 5 cm error in setup
 SAD to SSD setup, changes
 Dose calc for 4-field pelvis given TMR and depths
 Calc MU/deg factor for arc of certain angle
 Calc dose to point under block given diagram, TMRs for open & blocked fields, block transmission, dose to point in unblocked portion of field
 Gap calc (matching two hemi-body set-ups)
 Craniospinal junction – methods for matching fields
 For mantle field without compensation, which point receives most dose (axilla, cervical nodes,...)
 Combined photon/electron for parcial (why combine, typical ratio, ...)
 Wedge size, with field size, dynamic wedge issues...
 Compensator factor (Δ with depth, Δ with field size, independent of field size, use less than equivalent thickness of tissue, brass comparable to cerro)
 Matching: match the best diagnostic study (CT, MRI,...) with each anatomic site (prostate, glioblastoma multiforme ...)
 Disadvantages of using MRI for RTP
 Factors needed to determine size of tumor (TSD, TFD, etc)
 What can be determined from DVH
 General pros and cons of MLC
 3D BEV planning issues
 Critical structures relevant to backscatter from lead shields in electron beams (e.g. buccal mucosa)

SPECIAL TREATMENT PROCEDURES

Matching, match the special (IMRT, SRS, HDR, TSET, TBI) with the disease (myc fungoides, leukemia, glioblastoma multiforme, bile duct carcinoma)
 Given TMRs for neck and abdomen, calc lead to give equal midplane doses for TBI
 TBI calc – dose to ankle given info at midline and ankle with OLF
 Table requirements for stereotactic radiosurgery
 Purpose of dual fields for TSET
 Methods of IMRT (is includes wedge, dMLC, partial transmission blocks...)

How much is the energy of an electron beam for TSET degraded by 3 m of air

RADIATION SAFETY

Fetal irradiation (know what happens when irradiate during preimplantation vs. organogenesis, whether neurological damage results if radiate during weeks 8-16...)

Primary barrier calc

Neutron detectors

Matching, use & occupancy factors

HDR emergency procedures

Package labeling/labeling (know definition of TI, what needs to be on label, ...)

Source leakage limit

When can pt who received pharmaceutical leave hospital

Door shielding - what's needed from inside of door to outside

Know average energy of neutron distribution

Misadministrations – know %

Dose to fetus from mantle field of pregnant patient comes from...

QUALITY ASSURANCE

TG-40: includes QA for which (1st included brachy sources, chart review, CT sim...)

TG-40: Co-60 monthly QA tasks

TG-40: tasks to perform each time an electrometerion chamber system is used

TG-25: know specs for flatness, symmetry, uniformity index

BIOLOGICAL AND CLINICAL CONCEPTS

TDs (TD stands for..., first 5 stands for..., second 5 stands for...)
 Common late effects for thoracic irradiation
 Matching: Critical structures (...) associated with treatment sites (larynx, ...)
 Be able to put in order of escalating dose for cure (1st included: breast, Hodgkin's, seminoma, prostate...)
 Matching: match TDs values with correct organ (1st included: fetus, lung, optic chiasm,...)
 Know what PTV includes/reports
 Meaning of cc:β ratio
 Do on survival curve represents...
 Matching: match parts (arevoli, choroid,...) with anatomy (lung, eye,...)

$$f \rightarrow \text{focal spot}$$

$$f = F(m-1) = F(\frac{S_{ID}}{S_{OD}} - 1)$$

Specific heat \Rightarrow 1g water
 1°C

$$\text{ice } \frac{1}{2} \\ \text{steel } \frac{1}{8}$$

$$\rho_{\text{penumbra}} = f/m^2$$

ABR 2000 - Part 1 - Physics

1. Calculate the kerma deposited by a beam with a photon flux of X and the following values for μ/ρ / μ_0/ρ_0 .

2. Which of the following do not influence the MTF of film?

3. The threshold of hearing is $X \text{ W/m}^2$. A sound of $Y \text{ W/m}^2$ corresponds to how many dB?

4. Electron capture competes with which of the following processes?

5. Decay scheme is shown. Not all of the energies are labeled. You are asked to deduce total energy of the decay. The key here is to simply know the threshold energy of Beta plus decay.

6. What is natural background per year at sea level (including radon)?

7. A 16 bit computer can access how many locations?

8. One hexadecimal digit can be used to count up to what number?

9. Which of the following would have the highest LET?

10. Question on Blackbody radiation.

11. Which of the following lasers is not useful for fiber optic transmission? A series of laser types were listed along with the corresponding wavelength.

12. If 0.1 kg of water is cooled from 40°C to -80°C, how much energy is lost? Given specific heat of water, specific heat of ice, and an additional constant (thermal fusion constant).

13. According to the uncertainty principle which of the following cannot be measured simultaneously?

14. The area of a copper plate is 0.1 m^2 . The coefficient of linear expansion is provided. If the temperature increases from 22°C to 100°C, what is the new area?

15. If the workload of a machine doubles, by how much must the barrier thickness be increased?

- a. $\sqrt[3]{2}$ half value layer

- b. $\sqrt[3]{2} \times \Delta T$

- c. $\Delta A/A = 2 \times \Delta T$

- d. $\Delta A/A = 2 \times \Delta T + \Delta T$

- e. $\Delta A/A = 2 \times \Delta T - \Delta T$

- f. $\Delta A/A = 2 \times \Delta T + 2 \times \Delta T$

$$T = 4.856 \text{ hr}$$

$$\rho_g = 1000 \text{ g/l} = 1000 \text{ cpm} \\ R_B = \frac{19200}{30} = 640 \text{ rpm}$$

$$\rho_S = 1000 - 640 = 360 \text{ cm} \\ \delta = \sqrt{\frac{R_B}{t}} + \frac{R_B}{t} = \sqrt{\frac{360}{10}} + \frac{360}{10} = 360$$

17. Counting statistics. The gross count for 10 minutes was 10000 counts. The background count for 30 minutes was 19200 counts. What is the net count rate and its standard deviation?

18. Given the area of a detector and its distance from the source. What is the detector efficiency?

19. Assume a binomial distribution. 4 measurements are taken with a maximum deviation between 2 of 10%. What is the standard deviation?

20. Question on the stop of a camera.

21. Given attenuation coefficient. What percentage of the incident photons is absorbed between a depth of 1 and 2 cm?

22. What is the increase in the total equivalent dose for an AP versus a PA radiograph? $\Delta D_{AP} = \Delta D_{PA}$

23. A nonparalyzable records 450 cpm. It has a deadtime of x. What is the true count rate?

24. $D_{eq} = 0.5 \text{ Gy}$. 2 Gy is required to reduce the surviving fraction to 0.53. What is the surviving fraction if 30 Gy are delivered?

25. A bomb survival data is provided. What is the increase in relative risk for cancer for those who received greater than 0.1 Gy?

26. For a certain diagnostic test, you are provided with the number of true positives, true negatives, false positives, and false negatives. You are asked to determine the sensitivity of the test.

27. Effective half-life problem.

28. Doppler effect. Given velocity of train, calculate frequency of a sound measured by a stationary observer.

29. 1e15 bytes is $\frac{1}{4}$ petabyte, terabyte, gigabyte...

30. question involving rms voltage

- $V_{rms} = \frac{1}{2} V_{peak}$ for sin wave form.

- $\rho_{\text{penumbra}} = \frac{60 \text{ mg}}{52 \text{ week}}$

- $T = 1.9 \text{ years}$

16. How long can one spend 50cm from a patient with a 60mg radium equivalent implant, and not exceed the occupational limit applied to one week?

TEST: ABR Therapeutic Physics Exam

TEST DATE: September 2000

TEST FORMAT: 75 multiple choice questions to be answered in about 3 hours
 The first 50 questions were "easy" and worth 1 point each.
 The last 25 questions were "hard" and worth 3 points each.

Easy-type questions

(1) Given a picture of non-wedged profile cans obtained using a scanning water tank, question asked what was wrong with the superficial-most profile (which appeared somewhat wavy in comparison to the others). *wedge wave*

(2) One question regarding the spatial resolution of MOSFET detectors. Possible answers were in units of μm .

(3) Define wedge angle. *the angle through which an isodose curve is tilted at the central ray of a beam at a specific depth ($d = 10\text{ cm}$)*

(4) State which measuring device would be most appropriate for simulator shielding. *its angle between isodose curves and the normal to the central axis*

simulator \rightarrow KV tube \Rightarrow ion chamber 100cc

(5) How much dose is delivered from 1.25 kV after 45 days given its half-life and initial dose rate? $D = D_0 \cdot T_{1/2} \cdot (1 - e^{-t/T_{1/2}})$ $D = 0.59 \cdot 4 \cdot 1.44 \cdot (1 - e^{-45/5})$

(6) One question about reasons for using a parallel-plate chamber for measuring output of a 4 MV photon beam. *gradient effects*

(7) What is the NRC-required frequency of sealed source inventories? *\$35 - \$267 per year*

(8) One question related to a skyshine shielding calculation where person only needed to recall the formula for computing steradians given a diameter subtended and distance from source. $\Omega = \pi D_{\text{BSL}}^2 / d^2$

(9) How much does a linac's workload increase for a TBI given the treatment distance, rep rate at isocenter, and dose to be delivered to the patient per week. $W' = d^2 W$ for leakage

(10) Most probable use for a 9" "rem counter" (as described by Kahn on page 495 of 1994 ed of *The Physics of Radiation Therapy*). Question was about what this instrument was used to detect. Possible answers included photons, thermal neutrons, fast neutrons, combinations of neutrons and photons, etc.

For primary scatter leakage \rightarrow rem counter \rightarrow B^2 proportional counter \rightarrow surrounded by a inch

TBI workload $W = 200 \text{ rad/sr/week}$ $W = 0.21$ rad/min - loaded polyethylene sphere

Ex: Non TBI $W = 12 \text{ rad/sr/week}$ $W = 4 \text{ rad/week}$ $1600 \rightarrow 2000 \text{ rad/week}$

TBI dose = 12 rad/1 week $\frac{12}{52} = 0.23$

$W_{\text{primary}} = \sqrt{300 + 12 \times 4^2} = 300 + 192 = 255 \text{ rad/week}$ Thermal neutron - open neutron

$W_{\text{scatter}} \text{ from TBI patient, TBI barrier} = 255 \text{ rad/week}$
 300 rad/week

$W_{\text{total}} = 300 + 192 = 492 \text{ rad/week}$

- (11) Question on ICRU Report 50 diagram outlining the GTV, CTV, PTV, TV, & IV. Person was given an illustration of this diagram and asked to which volume the arrow was pointing. (For this exam it was pointing to the PTV.) *linear \rightarrow 10 Gy low energy dependence*
- (12) One question about the uses and limitations of LiF TLD detectors for use in a radiation therapy department. Specifically, their accuracy, linearity, etc. *3% precision*
- (13) One question about what is not modeled for a beam for a 3-D treatment planning computer. Possible answers included upper collimator jaws, lower collimator jaws, target, monitor chambers, or the mirror. (Answer: mirror since the beam does not pass through the mirror, and it does not act as a beam modifier.)
- (14) What's the TG-34 recommended dose limit to a pacemaker? (200 cGy) *200*
- (15) What's the dose to a kidney that will cause irreparable damage? *200 cGy* $\left\{ \begin{array}{l} 200 \text{ cGy} \rightarrow TD 5/5 \\ 200 \text{ cGy} \rightarrow TD 50/5 \end{array} \right.$
- (16) One question on use of bubble-type neutron detectors.
- (17) Which of the following can occur that does not require a full re-calibration of all beams and beam scanning for a linac? (possible answers: changing klystron, bending magnet replacement, MU chamber replacement, target replacement, or waveguide replacement)
- (18) Simple inhomogeneity calculations for photons. You're given physical densities, electron densities, and mass attenuation coefficients. $d_{eff} = d - 2(1 - CET)$ *about 5 or 6 questions on TG-51.*
- (19) About 5 or 6 questions on TG-56. *One TG-56 question about coefficient of variation of measured seed strength \Rightarrow 3% report to manufacturer.*
- (20) Other things to note: Both old and most recent units used throughout for brachytherapy and radiation protection problems. Expect to have to convert units. *at least 10% of seeds to check*
- (21) Hard-type questions or at least % or 2 radios *(3 points each)*
- (22) Several inhomogeneity calculations for electrons and protons were asked. Usually given physical densities, electron densities, and mass attenuation coefficients. These were a little tougher than the one or two given in the easy-type questions, requiring one to perform more steps or to solve using a slightly different method to arrive at the answer requested.

2004 Part 1 Writtens

The Physics Section of Part 1 consisted of 75 multiple choice questions in a three hour period. Each question was followed by five choices (A through E); there were no true/false questions. There was no differentiation between "easy type" and "hard type" questions as there has been in past ABR sample questions--there were simply 75 questions in three hours, one after another.

Several questions were dedicated to computer terminology and data management... Examples follow.

Q A CT scan with a 512x512 matrix and 300 images is compressed at 1.5:1 compression. The transfer rate is ~1.7Mbps/sec, how many minutes for the transfer? (You'd have to know the standard bit depth of a CT image).

$$1.1 \text{ min} \rightarrow 5.8 \text{ min}$$

2. A terabyte is equivalent to:

- a. 10E4
- b. 10E5
- c. 10E6
- d. 10E7

3. What category of storage is an optical disk that cannot be overwritten? WORM (Write Once, Read Many)

4. What is the name for a computer program that translates programming code into computer instructions?

- a. Operating system
- b. compiler
- c. CPU

Several questions were dedicated to counting statistics and uncertainty, such as

5. If a sample has 1600 total counts in 4 minutes and the background has 900 total counts in 3 minutes, the activity of the sample is 100 ± 14 cpm.

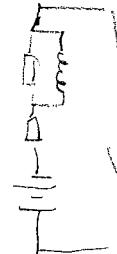
6. How many counts do you have to take of a sample to be 95% sure that you fall within 4% of your first count rate?

$$\sqrt{2} = 1.41 \quad N = 2500$$

There was one circuit:

Q Given a diagram of a circuit consisting of a battery, a resistor, and then a resistor and an inductor in series. Values for all of the components were given. The question was: what is the current through the resistor that is in parallel with the inductor at time $\rightarrow \infty$?

There were several questions relating to basic functions, and since it was a multiple choice test, it was pretty straightforward, such as:



8. What value of t gives this function its maximum value? $Y = 2t - e^t$

There were a few questions on ultrasound, such as:

Q Ultrasound transducers transmit and receive pulses using what effect? $e^{-\gamma t} + C$

10. US assumes 1540 m/s, but for fat, it's really 1460 m/s. An ultrasound image shows fat as being 2 cm thick. How thick is the fat really? 1.46 cm

There were several questions involving types of decay or interactions, such as:

11. C decays to D* by β^+ . D* cannot decay to the ground state by gamma emission. How can it decay?

- a. neutrino
- b. electron capture
- c. Auger electron
- d. Internal conversion

12. A 9.5 MeV photon passes by the nucleus of a lead atom. How many pair productions can take place? 1

There were a few basic isotope decay questions where you had to calculate an activity:

13. given a physical and biological half life, what remains after some time

14. given the parent half life and the much smaller daughter half life, what is the activity of the daughter in a long time?

A large number of questions related to HVL's and exponential attenuation, such as

15. given mass fractions of two materials and their attenuation coefficients, what is the combined attenuation in a compound?

16. how many HVLs is 6 TVLs?

Q If a patient is 8 HVLs thick, what's the ratio of entrance exposure to exposure at midpoint? $\sqrt[8]{2}$

18. Given an isotope that emits a high energy photon and a low energy photon. The low energy photon is emitted 4 times as frequently. Attenuation coefficients are given. What's the ratio of flow to high isotopes after traveling through 20 cm of water?

Q Given attenuation coefficients for lead and aluminum, how much aluminum is equivalent to x mm lead?

$$\frac{\ln 10}{TVL} = \frac{\ln 2}{HVL} = \frac{0.5}{FVL}$$

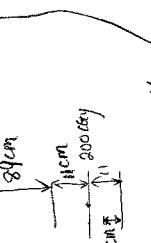
53. Superficial question. Measurement at end of cone gives a reading of 150.

Measurement at 10cm from the end of the cone gives a reading of 52.3. What is the effective SSD at the end of the cone.

54. No TG 61 \rightarrow

55. Purpose of the guard ring in a plane parallel chamber is to? A. "Define the collection volume" appeared to me to be the only reasonable answer.

56. A question where you were given air kerma and had to calculate roentgens from this. I think you just divide by 0.876 rad/R - this gave one of the answers.



57. Dose to cord from APP/A 100 SAD setup, 22cm separation, cord 4cm deep, 200cGy to isocenter. TMRs given. $\int \frac{D_{app}}{2} = D_{app} \cdot m_{app} = D_{app} \cdot m_{app} \cdot TMR(d=1)$

58. Most radiation sensitive part of the eye is ... $\frac{D_{app}}{D_{cord}} = \frac{D_{app} \cdot m_{app}}{D_{app} \cdot m_{app} \cdot TMR(d=8)}$

59. TVL is related to HVL by A: $TVL = \ln(10) / HVL$, B... other impressive but erroneous relationships.

This rule and it's generalization can be used to speed up all sorts of calc's, not just in $\ln(10) / HVL$!

60. Film exposed for dosimetry. Given transmitted light is 200 times smaller than original, what is the dose? OD vs dose table provided that required interpolation.

61. Electrons at extended SSD, which is true? $OD = \log \frac{D}{TVL} = \log \frac{D}{HVL} = 2.3$

A. Width of the 90% extends proportionately (B) Penumbra increases C. Output follows $\log(D/TVL) \propto ISL$ with 100 to source ...

62. What happens when you change from 15cm field size to 20cm field size for electrons. No energy given. Various combinations of change in surface dose (increase / decrease) and change in dmax (increase/decrease). Only one option had no change in surface dose (which I chose) \Rightarrow lateral scatter equilibrium \Rightarrow field equivalence \Rightarrow the same PDD along CAX

63. Why does the equivalent square technique work? A. Because scatter doses are equal at different output factors B. other options involved statement about collimators and scatter that sounded wrong

64. Scatter and leakage shielding thickness calculations are equal. The shielding that should then be used is: (A) $T_s + 1HVL$, B. other options including $T_s + T_L$, $T_s + 1TVL$, $(T_s \text{ or } T_L \text{ whichever is greater}) + 1HVL$

65. Order of materials in door for high energy linear \Rightarrow inside to outside. $\text{lead} + \text{PVC} + \text{lead}$

66. Electron backscatter from internal shield versus Energy and Z - just had to know increase vs decrease.

E backscatter \nearrow with $Z \uparrow$ \nearrow with $E \uparrow$



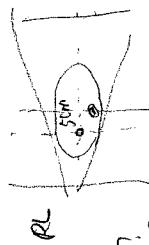
67. Four field prostate treatment to 200cGy. What is the dose to anterior rectum. No other information was given, anterior was in bold. I answered 200cGy.

68. What should you check with each use of an ionization chamber / electrometer. \rightarrow leakage, D, reionizing, potential D.

69. Classic isocentric PDD where you had to calculate the maxdose / midplane dose ratio. Given TMR table, output factor as a function of field size graph (normalized to 1.000 for 10x10), cGy/mm at dmax for 100cm SSD and 10x10, no Sc or Sp given anywhere in the test.

70. A 60Co single field calc 100SSD, cGy/min at dmax given. PDD table given, BSF D/T(0.7), BSF, PDD table given, TAR table given. Prescribed dose was 300cGy to 10cm deep. Had to use 4A/P to convert to square field (had to use 4A/P on numerous rectangular field questions).
71. Had to do single field 12.5 cm SSD calculation. 300cGy to 10cm deep. Given output factor as a function of field size graph (no Sc or Sp which in my opinion makes it impossible to do this question accurately), given PDD table, TMR table, given output at dmax for a 10x10 at 100cm SSD. Answers all very close ie approx 1% apart. $D = D_{app} \cdot m_{app} \cdot \frac{F_{100}}{F_{12.5}}$
72. Multiple beam plan. AP weighted to 100% at dmax, laterals weighted to 100% at dmax. 200 cGy delivered to 238.6 isodose line. Dose delivered by AP beam is ??? cGy. $200 / 12.5\% = 80 \text{ cGy} \rightarrow 100\% \text{ dose} \rightarrow AP \text{ beam}$
73. Monte Carlo calculations require a random number generator and ... A) probability distributions, B,C,D,E other options that didn't look right. So \rightarrow Monte Carlo \rightarrow Monte Carlo
74. Dose 10cm deep Sem outside field is A) 1% B) 2% C) 3% D) 4% E) 5% Exp F. in Katz book \rightarrow Monte Carlo \rightarrow Monte Carlo
75. F factors given on several questions were not what I expected for the isotope in question. But I always used the one given. If total dose $> 25\%$ power law factor should be applied \rightarrow $F_{100} / 100\%$
76. Pacemaker dose limit. \rightarrow T_{634} \rightarrow $100\% \text{ dose} \rightarrow 100\% \text{ dose}$
77. Apparent mCi is less / more / same as mCi \rightarrow encapsulation effect \rightarrow $269 \cdot 10^{-6} \text{ g}$
78. No shielding questions were simple "plug in and solve for B". Every one required something "non-standard" or use data in a non-standard format.
79. TG40 photon flatness specification: A 1% B 2% C 3% D 4% E 5%.
- X-ray beam flatness constancy = 2% \downarrow relatively ! If assume $F_S \rightarrow 20\text{cm}$ and no mu change \rightarrow $\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$ \rightarrow $\frac{1}{4} \cdot 20\text{cm} = 5\text{cm}$
- E beam flatness constancy : 3% \downarrow $\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$ \rightarrow $\frac{1}{4} \cdot 20\text{cm} = 5\text{cm}$

$$6.7 \times \frac{105}{760} = 7.035 \text{ cm}$$



26. Biggest impact on fetal dose according to TG36 (A) Distance to fetus, B. energy C. Blocking, D. Depth below abdomen surface.

(27) S/rho and rho given for lead. Calc MeV/cm then use to calc lead thickness needed to shield 18MeV beam. $\gamma\rho \cdot \rho = S \Rightarrow \text{thickness} = 18\text{MeV}/S = \text{cm}$

28. HDR 192Ir. Patient treated with time XXXX with Activity 15° on Aug 17th. Treatment time on Aug 22nd is ? No 192Ir-half life given. Increase of dose beyond lung to 4%/cm \rightarrow 40% per day. $t_X \text{ on Aug 22nd} = (\sqrt[15]{(1/272)} \cdot 43.7) \cdot 10^2 = (\frac{5}{272}) \ln 2 = 1.048$

29. Nothing on TBE/electron 30. 10MV through 6cm lung, dose actual vs dose without inhomogeneity. No other data given. Increase of dose beyond lung to 4%/cm \rightarrow 40% per day. $t_X \text{ on Aug 22nd} = (\sqrt[15]{(1/272)} \cdot 43.7) \cdot 10^2 = 1.048$

31. A question involving 10mg Ra - simple application of $t_X A/d_2$ - but needed to know (ie not given) exposure rate const. = 8.25 Rem/mg.hr

(32) Shielding question. 36 in space available for needed 6 TVL (this information was given). Pb TVL given. Concrete TVL given. What is the minimum thickness of Pb needed.

33. How many TVL's in a linac head. $0.1\% \Rightarrow 3 \text{ TVL}$.

34. No MLC questions

35. The only IMRT question: In IMRT the physicist does not define (A) Beam Weights B. Field Sizes C. Gantry Angles ...

36. Field size required at midplane is 25cm, maximum can open is 20cm. What is SSD? (separation = 22cm)

37. Sim film taken at 102cm SSD, SFD 140cm. Want to treat at 120cm SSD. What distance to film should be used when cutting blocks. $120 \times \frac{140}{102} = 165 \text{ cm}$.

38. Standard question about the couch kick angle required to make inferior borders parallel on lateral brain fields. For 10x10 field at 120 SSD, and measured arc 13.7°, SFD = 165 cm

39. Breast Tangent pair. Field widths at 100 SAD = 10.5 cm. O has gantry angle 45 degrees. What gantry angle does RPO have such that posterior borders will be parallel.

40. I'm vague on this one but I'll give it to you anyway. The question went like ... The simulator couch wouldn't go low enough, so the film was taken at X SSD, separation 25 cm, distance to film = 140 cm. Physician wants to treat at 132 SSD, simulator film needs to be placed at what distance to cut blocks.

$\tan \alpha = \frac{140}{X+17.5} \Rightarrow SFD = \frac{140}{X+17.5} \times (132 + 17.5)$

$\tan \beta = \frac{140}{X+17.5} \Rightarrow SFD = \frac{140}{X+17.5} \times (132)$

$\beta = \arctan(\frac{140}{X+100}) = \arctan(\frac{105}{205}) \Rightarrow \beta = 21.8^\circ$

$\alpha = \arctan(\frac{140}{X+100}) = \arctan(\frac{105}{205}) \Rightarrow \alpha = 21.8^\circ$

(41) No diagram with this one making it tough. Patient on simulator couch with isocenter 5cm right of midline. Wire placed at midline (didn't say A or P). R Lat film taken. Measured cord depth of 6.7cm, but therapist forgot to reset isocenter to midline. What is the true cord depth. If you think this is confusing, then I agree. Basically I think the depth was measured assuming isocenter at midline, then question was asking what is the true depth.

42. PDD for wedge increases over open field due to: A. Photon interactions in the wedge B,C,D,E,... other options that didn't look right. Beam hardening \Rightarrow high Energy

43. Beam steering vs gantry angle in a linac. Signals to steer originate from ion chamber ... various other options. Transmission ion chamber \Rightarrow Number dose rate & integral dose chamber and radial distribution

44. Considering a dual ion chamber scanning water tank, an error in the PDD (a shift up or down - I don't recall which) is not due to A. incorrect zero - ie set above water level B. RF interference (C) water / air temperature differential D. Stepper motors not calibrated correctly.

45. No electron Arc questions, no gamma knife questions, no SRS questions. Normalized relative measurement (Rp)

46. Electron cutout changed from 6x6 to 4x4. What doesn't change? A) Bremsstrahlung B. Chamber jaws Output Factor, C. Depth of 80%, D. Surface Dose.

47. ISO ionization depth of an electron beam is 5.1 cm. The energy of the beam is ...

48. Saturation in an ionization chamber refers to ... (A) voltage high enough to prevent recombination ... other options that were not correct.

49. A survey points a linac beam at a primary wall and measures 2mR/hr. Is this OK? There were various options in the answers, but this was the point of the question.

50. An ion chamber is used to perform a survey. You also need all of the following except: A. Dose rate of linac B. Sufficient buildup around the survey meter C... other options that looked to me like they were required.

51. SAR for this radial section: Diagram given, table of SARS given.

52. Classic electron ISL calculation straight from Kahn, ie calculate the effective SSD, given energy, field size, dmax (2cm), given slope of $(\log E)^2 = 0.0111$.

done with $\frac{I_o}{I_g} = \left(\frac{f + dm}{f} \right)^2$

gap between gap and surface.

$\delta = 90^\circ - 2\beta$

$\alpha = 360^\circ - (90^\circ - \delta) + \gamma$

$= 360^\circ - [90^\circ - \gamma + (90^\circ - 2\beta)]$

$= 180^\circ + \gamma - 2\beta$

$$\begin{aligned}
1. \quad A &= D_{A1} + D_{A2} + D_{A3} \\
&= DR \cdot T_1 + DR \cdot T_2 + DR \cdot \left(\frac{1}{\sqrt{3}}\right)^2 \cdot T_3 \quad \Rightarrow \quad D_A = DR \cdot T_1 + DR \cdot T_2 \\
&\Rightarrow \quad 0.2 \cdot T_1 = 0.5 \cdot T_2 \\
D_B &= D_{B1} + D_{B2} = DR \cdot T_1 \left(\frac{1}{\sqrt{3}}\right) + DR \cdot T_2 \left(\frac{1}{\sqrt{3}}\right)^2 \quad \Rightarrow \quad T_1 = 2.5 \cdot T_2 \\
2004 \text{ ABR Therapy Part 2, Written.} &= DR \cdot T_1 + DR \cdot T_2
\end{aligned}$$

Dose points A, B and C 1cm perpendicular to dwell positions 1, 2 and 3 respectively.
Dwell times in 1 and 3 are the same. What is the ratio of dwell times 1 to 2 to make dose A equal dose B.

1. HDR, three dwell positions (1, 2 and 3 – in middle) 1cm apart in single channel.
Dose points A, B and C 1cm perpendicular to dwell positions 1, 2 and 3 respectively.
Dwell times in 1 and 3 are the same. What is the ratio of dwell times 1 to 2 to make dose

$$P_{\text{dwell}} = \frac{|T_{\text{max}} - T_{\text{min}}|}{2m \cdot n_{\text{dwell}}}$$

[]

③ Simulator shielding question. NCRP 116 level to worker with office above simulator room. Occupation mentioned – I don't recall but was an allied health professional related to radiation oncology/radiology. Floor to floor = 12 ft, iso = 48" above floor, SAD = 100cm, given U=1/4, W=800mA, min/wk. Asked to work out the thickness of concrete shielding required. Answers about 4mm apart. Provided with a graph of R/(mA, min) at iso on vertical axis (log scale) vs concrete shielding thickness (cm) on horizontal scale – with the log scale, the plot was reasonably linear. Basically I think what you had to do was find allowed R/mA, min at point where person is sitting, then project back to iso to give your number for the Y axis then read across to get concrete thickness.

4. A/P/PA doses given from each field to cord for 200 cGy to tumor. (62cGy, 150cGy respectively). Cord block put in PA, new cord dose is 18% of original. How many fractions need cord block to limit cord dose to 40Gy? $\frac{62}{x} = \frac{40}{18}$ $x = 110$

efficiency $\in \frac{x \text{ (cpm)}}{\gamma \text{ (cpm)}}$ Counts given (cpm) for reference source with known activity (mCi). How many counts allowed to stay below wipe test leakage limit – limit not given (5mCi).

$\frac{1}{(5 \text{ mCi})} \times \frac{X \text{ (cpm)}}{Y \text{ (cpm)}} \times \frac{A \text{ (mCi)}}{T \text{ (R/cm}^2/\text{hr, mR)})} \cdot \left(\frac{1}{2}\right)^{24} \text{ hours} \cdot \left(\frac{1}{300m}\right)^2 = 0.05 \text{ R/hr}$

7. Parts definitely not included in EPID – options were ion chamber, CCCD camera, mirror, silicon screen, some other dose detection device. Metal fluorescent screen

8. TBI, diode reading 450cGy on surface, presc midline 600cGy/POP laterals, 30cm separation. TMR's given, 350cGy SSD. What is error in midline dose? Answers approx 5% apart, both + and -. I had to assume entry beam only, and diode reading relevant to dmax (not surface – no TMR at surface given to get anything reasonable).

EPID metal plate with solid state detectors (silicon diodes)
Fluorescent screen → replace by fibers optics
mirror → CCD/Video camera

$$\begin{aligned}
D_A &= D_{A1} + D_{A2} + D_{A3} \\
&= DR \cdot T_1 + DR \cdot T_2 + DR \cdot \left(\frac{1}{\sqrt{3}}\right)^2 \cdot T_3 \quad \Rightarrow \quad D_A = DR \cdot T_1 + DR \cdot T_2 \\
&\Rightarrow \quad 0.2 \cdot T_1 = 0.5 \cdot T_2 \\
D_B &= D_{B1} + D_{B2} = DR \cdot T_1 \left(\frac{1}{\sqrt{3}}\right) + DR \cdot T_2 \left(\frac{1}{\sqrt{3}}\right)^2 \quad \Rightarrow \quad T_1 = 2.5 \cdot T_2 \\
2004 \text{ ABR Therapy Part 2, Written.} &= DR \cdot T_1 + DR \cdot T_2
\end{aligned}$$

Arc $\theta = 150^\circ$.
 $d_{\text{eff}} = 15.9 + 0.1 \cdot 33 = 8.9 \text{ cm}$

9. Three beams 120 deg apart, AP and post oblique. Each 15 cm depth to calc point. 60cGy from each beam to be delivered to calc point. Post beams have 9cm lung, e density = 0.33, TMR's given at 3,6,9,12,15 cm. Ratio of mu's post to ant.

10. Several TMR and PDD questions that needed the 4A/P rule.

11. Extended SSD calc that needed the Mayneord F Factor. Was only given a graph of output vs field size ie could not separate Sc and Sp.

12. Ratio of dmax (25 MV) / dmax (4MV) for same dose to midline using POP setup with SSD = 100cm. PDD's given.

13. Neutron dose equivalent (mSv) outside field per photon Gy at isocenter. $\frac{(\text{Neutron dose equivalent ratio})^2}{(\text{Photon dose equivalent ratio})^2} = 18 \text{ MV vs 15 MV}$. Answers were fairly widely separated ie 1, 2, 5, 10, 100. []

14. Given distance d_{eff} , distance to maze and maze length, neutron dose at iso (mSv) per photon what is neutron dose (mSv) at door per photon cGy at iso. Told TVL of neutrons is 5m, but not where it applies. I applied kersey formula, ie ISL iso to maze, then 5m TVL down maze to door. $H = \frac{No \text{ cGy}}{mSv/gy} \cdot \frac{50}{SI} \cdot \left(\frac{d_{\text{eff}}}{d_{\text{TVL}}}\right)^2 \cdot \left(\frac{10}{10}\right)^2$

15. Numerous questions of dose ratio where had to use TMR ratio and change of ISL.

16. Dual scattering foil in linac, when change to electron mode (from photon) what happens. A) gun current reduces substantially, B. Both scattering foils are in place C. other options that were way off. beam current is higher in photon mode for right E electrons

17. Dual scattering foil in linac, when change to electron mode (from photon) what happens. A) gun current reduces substantially, B. Both scattering foils are in place C. other options that were way off. beam current is higher in photon mode for right E electrons

18. $\frac{A}{g(t)}$ for 125I vs 103Ru. A. same at all depths, B. Pd exceeds I beyond 1cm, C Pd exceeds I beyond 4cm. D) exceeds Pd beyond 1cm, E. Same at all depths.

19. No TG21 questions

20. No gamma knife questions

21. No ion chamber current from exposure rate or dose rate or in part 1 either. $\Rightarrow 3\%$

Electron X-ray beam flatness constraint $\Rightarrow 2\%$

22. TG 40 photon flatness spec.

23. TG40 field size spec A. 2mm/1%, B. 2mm/2% C others not 2mm

24. TG40 how often do you check well chamber leakage. A. 2 years B. Every use, C... \Rightarrow 0.1% leakage, on patient potential should be checked. Each use.

For both local standard and field instruments

leakage, on patient potential should be checked. Each use.

Table IV.