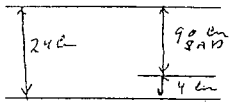
1. Several questions concerning the NRC regulations. (see below)
2. Calc. dose to cord

Given



3. Many questions in TG 41.
4. Some TG 30 questions. → TSKE
5. also TG?? On electrons.
6. Dose to patient on Linac x3} 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, Γ 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 μ/ρ H2O and muscle etc.
13. Thickness of Al needed to compensate for missing tissue. Factors given. ⇒
14. Sc 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 polly on outside, what is the energy of the gamma coming off polly? Given choice of answers 10 KeV neutrons, 10 KeV photons, .5 MeV photons, 100 KeV photons and 10 Mev photons.

↳ polyethylene

17. questions on acceptance checks for wedge factor. See below
18. In commissioning a new linac with 6 and 18 photons and electron up to 20 MeV you should 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 Γ and T1/2 etc.
22. Calc dose from Ir after 45 days. Given Do= 8cGy hr T1/2 must convert days to hours etc.

$D = \dot{D}_0 \cdot T_{avg}\left(1 - e^{-\frac{\ln 2}{T_{1/2}} t}\right)$

$= 8\text{cGy/hr} \cdot (73.8 \times 24) \times \left(1 - e^{-\frac{\ln 2}{73.8} \cdot 45}\right)$

=

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).
26. What is allowable dose to frequently exposed member of public? infrequent - 0.5 rem. 0.1 rem = frequent
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) T
29. Target of therapy x-ray unit not transmission type (T-F). F
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)
34. You can drill/screw into a depleted uranium collimator? (T-F) F → generate airborne particles
35. Linac jaw are made from natural uranium? (T-F) F
36. Natural uranium is commonly used as jaw material for linacs. (T-F) F
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

EC → γ emission.

EC 100%
0.035 MeV

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 ✓
    c. wedge factor vs. Off access
    d. wedge factor for the average chamber reading with gantry at 0 and 180 degrees.

radioactive

depleted uranium contains ^{235}U with a concentration lower than 0.711% occurring in nature

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 ½ 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

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

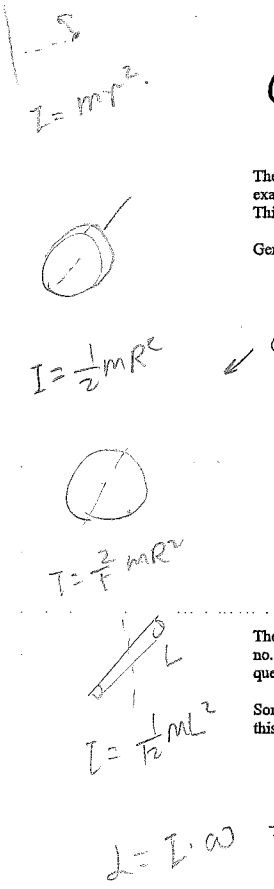
(3) Hall for Radiobiology and especially effects of radiation

(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 rad = 1 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 finshed 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 the 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 a 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^{-ux} 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.

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 point each)**

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

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

(3) Define wedge angle.

(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, hand-held 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 I-125 after 45 days given its half-life and initial dose rate?

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

(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.

(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.

(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.

(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.)

(12) One question about the uses and limitations of LiF TLD detectors for use in a radiation therapy department. Specifically, their accuracy, linearity, etc.

(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)

(15) What's the dose to a kidney that will cause irreparable damage?

(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.

(19) About 5 or 6 questions on TG-51.

(20) One TG-56 question about coefficient of variation of measured seed strength before you should notify the company of any discrepancies.

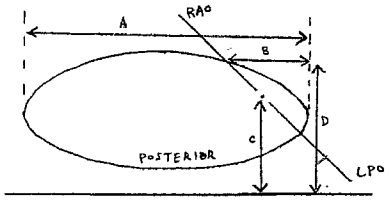
Other things to note: Both old and most recent units used throughout for brachytherapy and radiation protection problems. Expect to have to convert units.

Hard-type questions **(3 points each)**

(1) Several inhomogeneity calculations for electrons and photons 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.

(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.



(4) 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.

(5) 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 d_{max} 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.)

(6) 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.

(7) Some legitimate, clinically relevant questions on make-up doses for mistreated 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.)

HDR Calibration

(R/h) @ 1m in air

$S_K = 8.76\times10^{-3} \dot{X}$ (m^2 uGy/hr) (8)

$S_K = I \cdot P_{TP} \cdot P_{elec} \cdot N_C \cdot A_{ion} \cdot P_{ion}$

I: current reading; P_{TP}: T-P correction; P_{elec}: electron meter correction factor (9)

N_C: chamber calibration factor; HDR calibration

A_{ion}: chamber ion recombination correction at the time of chamber calib (10)

P_{ion}: recombination correction at source calibration

$\dot{D} = S_K \cdot \Lambda \cdot \frac{G(r,\theta)}{G(r_0,\theta_0)} g(r) \cdot F(r,\theta)$

Assume both SSD setup dme dmp can be found on PDD table

$D_{3cm\text{-}p} = D_{dmp} \cdot PDD_p(d=3)$

$D_{3cm\text{-}e} = D_{dme} \cdot PDD_e(d=3)$

$D_{3cm\text{-}p} + D_{3cm\text{-}e} = 55$

$D_{s\text{-}p} = D_{dmp} \cdot PDD_p(d=0)$

$D_{s\text{-}e} = D_{dm} \cdot PDD_e(d=0)$

$D_{sp} + D_{s\text{-}e} = 40$

$D_{med} = M \cdot N_{gas} \cdot \left(\frac{\bar{L}}{\rho}\right)^{med}_{air} \cdot P_{ion} \cdot P_{rep} \cdot P_{wall}$

Had to determine if a linac 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-21?

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.

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 polyethelyene, etc. ⇒ lead & BPE

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/Ci hr instead of 3.26 R cm²/mCi hr. All answers were ≥ 1 HVL.

0.0005 mGy/hr · 0.05 mR/hr ↑ 40 hr/wk 0.002 mSv/wk and 2 mR/hr only

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.

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

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

$e^{-(\mu \cdot TVL)} = 0.1$

$\left(\frac{1}{2}\right)^{HVL} = 0.511$

$-\mu \cdot TVL = \ln(0.1)$

$HVL = 1$

$\mu = \frac{-\ln(0.1)}{TVL}$

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

$\left(\frac{1}{2}\right)^{n'} = B$ $\quad n' = \ln B / \ln\left(\frac{1}{2}\right) = -\ln B / \ln 2$

$f = F(m-1) = F\left(\frac{SID}{SOD}-1\right)$ (f: focal spot; penumbra)

1 cal ⇒ 1 g water 1°C

1 cal = 4.19 J

Specific heat ⇒ # of cal to ↑ T by 1°C

Ice ½

Steel ⅛

MDA $= 3\sqrt{\frac{R_b}{t}} = 33$

$R_g = 10000/10 = 1000$ cpm $R_b = \frac{19200}{30} = 640$ rpm

$R_s = 1000 - 640 = 360$ cpm $\Delta = \sqrt{\frac{R_a}{t_1} + \frac{R_b}{t_2}}$

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_{tr}/ρ. (J/m²)
2. Which of the following do not influence the MTF of film? (focal spot size, SOD, recon)
3. The threshold of hearing is X W/m². A sound of Y W/m² corresponds to how many dB? $10 \log \frac{Y}{X}$
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? 2.94 − 0.28 = 2.66 ? 2 + 0.26 = 2.26 ?
7. A 16 bit computer can access how many locations? 2^{16}
8. One hexadecimal digit can be used to count up to what number? 15
9. Which of the following would have the highest LET? α 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 40C to –80C, how much energy is lost? Given specific heat of water, specific heat of ice, and an additional constant (thermal fusion constant?). E_w 40→0 E_w → E_i 0→−80°
13. According to the uncertainty principle which of the following cannot be measured simultaneously. position & momentum
14. The area of a copper plate is 0.1 m². The coefficient of linear expansion is provided. If the temperature increases from 22C to 100C, what is the new area? $\Delta A/A = 2\alpha\Delta T$
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?

$\frac{dX}{dt} = \Gamma \cdot \frac{A}{r^2}$ $D = \frac{1}{\rho} \cdot \frac{dX}{dt} \cdot T$ 100 mSv/y → 2 mSv/week.

$\frac{50\,mSv}{52\,week} = (60mg \times 8.25\,R^2cm^2/mg.hr) \times \frac{1}{50^2} \times T(hr)$

$T = 4.856\,hr$

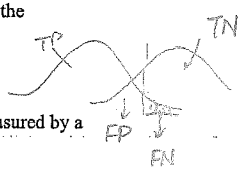
17. Counting statistics. The gross count for 10 minutes was 10000 counts. The background count for 30 minutes was 19200 counts. What is the net count rate and its standard deviation? $= \sqrt{\frac{10000}{10} + \frac{360}{30}} = 148 \pm 15$ 360 ± 15 cpm
18. Given the area of a detector and its distance 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? $b(x,n,p) = \binom{n}{x} p^x (1-p)^{n-x}$
20. Question on the f-stop of a camera. $f\# = 2$ $f\# = \frac{f}{diameter}$
21. Given attenuation coefficient. What percentage of the incident photons is absorbed between a depth of 1 and 2 cm? $= I_0 / I_1 / I_2$
22. What is the increase in the total equivalent dose for an AP versus a PA radiograph? The dose to each organ (breast, thyroid, lung, and heart) is provided along with w_T for each. NO ln2 here!
23. A nonparalyzable records 450 cpm. It has a deadtime of x. What is the true count rate? $R_t = R_0/(1 - R_0 t) = R_g = R_t e^{-R_t t}$
24. Dq= 0.5 Gy. 2Gy is required to reduce the surviving fraction to 0.53. What is the surviving fraction if 30Gy are delivered? $0.53 = e^{-2/D_0}$ ⇒ $D_0 = 3.154$ Gy ⇒ $\log_e n = \frac{D_q}{D_0} \Rightarrow n = e^{0.6} = 1.7$ $\frac{N}{N_0} = [1-(1-e^{-30/3.15})^{1.7}] = 1-(1-e^{-30/3.15})^{1.7} = 0.000085$
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% → 8 %/Sv
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. $S = \frac{TP}{TP+NF}$
27. Effective half-life problem.
28. Doppler effect. Given velocity of train, calculate frequency of a sound measured by a stationary observer. $f'' = \frac{v - v_s}{v} \cdot f$
29. 1e15 bytes is a petrabyte, terabyte, gigabyte…
30. question involving rms voltage $V_{rms} = \frac{\sqrt{2}}{2} V_{peak}$ for sin wave form.

$I_2 = I_1 \cdot \exp(-u)$

$I_1 = I_0 \exp(-u)$

$I_2 = I_0 \exp(-2u)$

$\Delta I = \frac{I_1 - I_2}{I_0} = \frac{I_0 \exp(-u) - I_0}{I_0} = \exp(-u) - \exp(-2u)$



in water

photon energy (MeV)	τ	σ	π
0.01	95	5	0
0.026	50	50	0
0.150	0	100	0
24	0	50	50

ABMP part II (July 2000)
Chicago

- Similar questions to those listed in this book for ABMP 1999, part II. Also:
- Define brachytherapy functions, g, F, Λ — Λ → dose rate constant in water (cm^{-2}); g → radial dose function; F — 2D anisotropy function; G — geometry function
- Prescribed doses in TBI w/ photon and electron — TBI → midpoint ⓐ umbilicus. 800 cGy ~ 1375 cGy
- Prescribed doses in SPS, SRT, breast, prostate, seminoma — TBE → 30 Gy 3660/qwk for mycosis fungoides
- 3-field treatment, 180cGy, gantry120deg apart, equally weighted, lateral beams pass through 6cm lung, what dose actually absorbed? higher dose TAR(d eff)/TAR(d)
- Particle accelerators can accelerate positive ions (cyclotron), 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? (yes / yes / ? / Yes)
- 6x, 100cm SSD, d=10cm, PDD=.73. Same beam used for SAD. What's TMR @ d=10cm? $TMR = PDD(f, r, d) \cdot \left(\frac{f+d}{f+dm}\right)^2 \cdot \frac{Sp(rdm)}{Sp(rd)}$
- Brachytherapy definitions: anisotropy / geometry / radial functions
- Use of re-entrant ion chamber in brachytherapy source calibration
- Earlier NIST shortcoming in anisotropy function calculation of I-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! penumbra?

	Per hr	per year
off	0.002 rem Avg 0.01 rem max	
on, outside	restrict <1.25 rem/quarter 5 rem/year	
	unrestricted 0.002 rem/hr 0.1 rem/wk	0.5 rem/y

typical DR for

point A	point B	bladder surface

uterus 子宫 uterine
ureter 输尿管

Table 5.2 khvh ← 0.026 MeV

bending magnet, target, primary collimator, flattening filter, ion chamber, collimator

Diode: high spacial resolution, high sensitivity, rad damage, E dependency

$r_d = r \cdot \left(\frac{f+d}{f}\right)$ $r_m = r \cdot \left(\frac{f+dm}{f}\right)$

hot spot in photon, cold spot in e⁻

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 tissue? — none of this
Compton interactions - energy of backscattered photon 0.256 MeV
Know energy where photoelectric and compton interactions are ~ equally likely
Properties of Co-60 decay two γ photon per disintegration 1.17, 1.33 MeV ⇒ 1.25 MeV; $T_{1/2} = 5.26$ y

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: α, N_x, A_{wall}, N_{gas})
Put the parts in tx head in order (list included: monitor chamber, target, collimators...)
Matching: match linac parts with appropriate functions (list included: magnetron, circulator, waveguide...) — magnetron: produce/generate microwave; circulator: prevent RF power reflecting back to RF source; waveguide: transport power from microwave power source to accelerator tube
Given MHz, calculate the size of each microwave cavity ——→ ?
kV issues(heat vs. brem efficiency, heel effect, output proportional to...)
MV transmission target properties ——→ <15 MV high Z; 15 MV low Z
Methods to measure dynamic wedge
Methods of instant verification for in vivo dosimetry
Properties of LiF TLD ——→ 10 Gy linearity, less E dependency, Zeff similar to tissue
Properties of diodes
Problems with using film for measuring PDD relative calibration; air gap extended

EXTERNAL RADIATION BEAMS

Matching: match electron energy with "rule of thumb" values (know R_p, %brem, R_{50}...)
Factors that affect virtual/effective SSD ——→ E, field size
Ideal properties of a phantom for an electron beam ——→ Zeff, Pe ⇒ the same linear stopping power, linear angular scattering power
If chamber in water phantom goes 5mm deeper on one side of CAX change in msmts =?
Properties of photon isodose lines
Most sensitive energy test ——→ flatness, output, dmax, R80, R90, skin dose
When electron beam is collimated to small field, what happens to output
Dose distribution for abuting electron and photon fields
What factors inc geometric penumbra = s · (SSD+d−SCD)/SCD
Issues when increase cone to skin distance for electrons

BRACHYTHERAPY

Calc air kerma strength from mgRaEq for Ir-192 ⇒ Y mgRa × 8.25 R cm²/mCi·hr · 8.76×10³ m²·μGy/R
Know typical DR for fletcher at: point A, point B, bladder, surface = Y · (7.27) × 10⁻⁴ cm²/m² × 10³ = 7.27 mGy·m²/hr
Matching: match isotopes with appropriate factors (know HVLs, half-lives, average/max energies...)
Given DR at 1 cm perpendicular to Cs-137, what is the DR at 0.5 cm ——→ Ir indistinguish from I/S law up to 5cm
Calculate DR at 1.5 m given mg of implant, Γ, 25% atten by pt, and a TVL shield
Know what point A represents ——→ the uterine vessle cross the ureter
Factors affecting Sievert integral
Prostate implant issues (TRUS, typical doses, urethral complications wrt EBRT...)
Given total dose from permanent implant, calc dose delivered at point in time $D = (\dot{D}_{TAvg})(1 - e^{-\lambda t})$
Matching: match the essential info (ISL, exposure rate constant, 8.25 Rcm²/mgh...) with the source strength specification (mgRaEq, Air Kerma strength, apparent activity...)

but for 0.5cm its less than the length of Cs source.

RADIATION TREATMENT DESIGN

Esophageal tx planning (typical beam arrangement, does it depend on which 1/3, ...)
Lung tx planning – issues related to 6MV vs 18MV for small midlung lesion (e.g. build-up and build-down effects)
Calc dose from PAB given information for SCLAV

Calculate dose at cord given dose at prescription depth
Calculate total dose given several beams which traverse sevl 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 recieves most dose (axilla, cervical nodes...)
Combined photon/electron for parotid (why combine, typical ratio, ...)
Wedge transmission factor (Δ with depth, Δ with field size, dynamic wedge issues...)
Compensators (list included: independent of depth, 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 OAF
Table requirements for stereotactic radiosurgery
Purpose of dual fields for 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 rads during weeks 8-15...)
Primary barrier calc
Neutron detectors
Matching: use & occupancy factors
HDR emergency procedures
Package 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 electrometer/ion chamber system is used
TG-25: know specs for flatness, symmetry, uniformity index

BIOLOGICAL AND CLINICAL CONCEPTS

$TD_{5/5}$ (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 (list included: breast, Hodgkins, seminoma, prostate)
Matching: match $TD_{5/5}$ values with correct organ (list included: fetus, lung, optic chiasm...)
Know what PTV includes/represents
Meaning of α:β ratio
D_0 on survival curve represents...
Matching: match parts (alveoli, choroid,...) with anatomy (lung, eye,...)

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 59Co 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 Do, n, what is Dq
- 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, Nx, Pion, Prepl, 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.

angular momentum, for particle:

$L = r \times p$ (p: linear momentum)

$= mvr \cdot \sin\theta$

for circular: $L = mvr$

angular momentum for subject:

$L = I\omega$

ABR Written Exam 2002

General Physics:

moment of inertia (rotational inertia)

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

A question about the angular momentum. $I = mr^2$ ($= \frac{2}{5}mr^2$ ball) $K = \frac{1}{2}I\omega^2$ (kg·m²; ↳ rolls) $L = I\omega$

A weight is stiing on a beam that is supported by two cloumns. Given the location of the weight on the beam, calculate the force on each beam.

A electron travels from the cathode to anode (Voltage and distance was given). How long it take for the electron to travel this distance. $eV = \frac{1}{2}mv^2 = \frac{1}{2}mc^2\frac{1}{1-(\frac{v}{c})^2} \Rightarrow V = ?$ $V_{av} = \frac{1}{2}V$ $t = \frac{d}{V_{avg}}$

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. $= 0.4e^{-\frac{\ln 2}{T_1}t} + 0.6e^{-\frac{\ln 2}{T_2}t}$ $A = A_0 \cdot e^{-\lambda t}$

Two isotope 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 (desities were given)

A question about the pulse repetition frequency of a ultrasound transducer. The focal depths was given same $\Rightarrow \theta = \frac{1.22\lambda}{d}$ $L = d^2/4\lambda$

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. 40 dB

RC circuits.

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

Beta plus decay, amu's are given. Calculate the max energy of the positron.

The hex equivalent to a binominal number.

Calculation of accumulated dose 1.44 $A^\circ T_{1/2}$

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

$A = A_0 \cdot e^{-\lambda t}$ ↳ $T_{1/2} = 60.2$ days

$\tilde{A} = \int_0^\infty A(t)\,dt = 1.44\,T_e A_0$

f↑ ⇒ focal depth↑

Q↑ narrow band width ⇒ doppler

Q↓ broad ⇒ better axial resolution

f↑ ⇒ better axial resolution

⇒ ↓ imaging depth (L↑)

⇒ less divergency (Q↓)

if tell you uptake half life T_u ⇒

uptake if ~~effective~~ is not rapid in compared with T_P

$\tilde{A}_u = 1.44 A_0 T_e (T_{ue}/T_u)$ ↳ biologic uptake

effective uptake half life

$\frac{T_B T_P}{T_B + T_P}$

$T_{ue} = \frac{T_u T_P}{T_u + T_P}$

f↑ λ↓ L↑

$2^{?6} = 64$

$\frac{512 \times 512 \times 6}{X}$ bit/s

Image of 512x512, gray scale of 64, info transmitted at X baut rate, how long does it take

Two batteries are connected in series through a resistor. One of them is flipped, what is the new current.

A 2 tesla MRI scan. The sample has a contamination of 10 ppm. What is the noise that is introduced.

Clinical:

Where is the foramen Magnum.

What is Meiosis

Where are the adrenal glands.

What makes the gall bladder contract. fat.

Flow of blood through heart.

How many cranial nervers are there 12

If a patient is dehydrated, the patient lacks ??? Sodium Na^+

What do you use a thallium scan for

What scan do for a Hiatal hernia barium x-ray endoscope gastroscope

Function of cerrebellum

Function of spleen

What connect the two cerebral hemispheres → corpus callosum ↔ corpus luteum

Male chromosome are ~~XY~~ or XX

★ Graph of two survial curves, What is identical (Do, Dq, n, OER)

Order of the small intestine duo- Ileum Jejunum

What causes portal hypertension liver sclerosis → cirrhosis

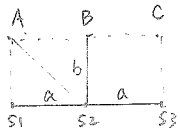
Which artey is the main blood supply for the liver portal.

	prone			supine		
	RL	LL	PA	RL	LL	PA
γ_1	γ_{16}	γ_{16}		γ_{16}	γ_{16}	
γ_2			γ_{25}			γ_{25}
G	90°	270°	0°	270°	90°	180°
coll	$\theta = \tan^{-1}(\frac{\gamma_{25}}{100})$	$360° - \theta$	0	0	$360° - \theta$	0°
couch	$360° - \alpha$	$\alpha = \tan^{-1}(\frac{\gamma_{16}}{100})$	0	0	$360° - \alpha$	0°

toward gantry

G=270° Couch=90° G=90° couch=270°

α 0 $360° - \alpha$



$D_A = A \cdot (\frac{1}{b})^2 + A(\frac{1}{a+b})^2 + A(\frac{1}{\sqrt{(2a)^2+b^2}})^2 = A \cdot [\frac{1}{b^2} + \frac{1}{a^2+b^2} + \frac{1}{4a^2+b^2}]$

$D_B = A(\frac{1}{\sqrt{a^2+b^2}})^2 + A \cdot \frac{1}{b^2} + A \cdot (\frac{1}{\sqrt{a^2+b^2}})^2 = A \cdot [\frac{2}{a^2+b^2} + \frac{1}{b^2}]$

$D_A/D_B = \frac{1/b^2 + 1/a^2+b^2 + 1/4a^2+b^2}{2/(a^2+b^2) + 1/b^2}$

2003

Part II, Therapy:

Lots of shielding questions

How often do you calibrate the barometer 3 month TG-40. 1mm/Hg

A concrete wall (66 inches) is to be replaced with a thinner wall (36 inches) consisting of concrete and steel. TVL of steel and concrete were given. Calculate the steel thickness.

Lots of MU calcs, SSD to SAD, Entrance-Exit dose, extended SSD. $\begin{cases} \frac{66}{TVL} = \frac{x}{TVL} + \frac{y}{TVL} \\ x+y=36 \end{cases}$

TG-51: for photon calibration, above how many MV do you have to use how thick a layer of lead at how many cm from the source? 10 1mm 50±5cm

How much difference will the calibration be by using TG 21 and TG51 for photons? 1% higher, 3% higher, same, 1% lower, 3% lower. Ratio of TG51/TG21 ~ 1% ← {0.9% 6mV, 1.0% 18mV, 1.3% 25mV

the uncertainties of the ratio is 1.5%

A brachytherapy line source, with thee separate sources. What is the differnce in the dose rate for a point perpendicular to the center source relative to a point perpendicular to the end source.

What is the difference in a baormeter reading if the readings are taken aa a height of X and X+50 m.

What does the term sliding window mwan in IMRT

Couch kick on a cranial spinal treatment.

A sim-film is taken for a 100 SSD setup. Patient is treated at 80 SSD. What is the assumed Souce-to-Film distance to correctly cut the blocks for the new 80 SSD.

For a x ray tube with 100 mA and 100 kVp, the HU has a sigma of 1.5, if the current is raised to 400 mA, what is the new sigma of HU?

$P = P_b \cdot \exp[\frac{-g_0 m (h-h_b)}{R^* \cdot T_b}] = P_b e^{-\frac{0.029 \times 9.8 \times (h-h_b)}{8.3143 \times 273.15}}$

$= P_b e^{-\frac{0.000025 (h-h_b)}{\text{at } 0°}}$

$= P_b e^{-\frac{0.0342}{T} \cdot \Delta h}$ ↑ if T in (273.21°)

P_b – static pressure

T_b – standard Temp

h – height above see level

R – 8.31432 N·m/mol·K

g_0 – gravity 9.8 m/s²

m – molar mass of earth's air 0.028kg/mol

$mag = \frac{SFD}{100}$

$mag = \frac{SFD'}{80} \Rightarrow SFD' = \frac{80}{100} SFD$

$\delta = \frac{1}{\sqrt{N}} \Rightarrow \delta = 15 \times 1/\sqrt{400/100}$

$= 15/2$

$= 0.75$

the primary standard used for chamber calibration.

0.5% due to data, procedures

the rest is due to the change in

22 (1) Dose weighting between open and wedge fields: $W_O + W_W = 1$

$W_W = \frac{\tan\theta_{eff}}{\tan\theta}$ $\quad W_O = 1 - W_W$

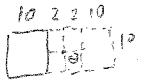
$W_W = \frac{\tan 30}{\tan 50} = 0.333$ $\quad W_O = 1 - 0.333 = 0.667$

(2) $MU_W = \frac{Dose \cdot W_W}{TAR \cdot S_c \cdot WF(WHF)}$ $\quad MU_O = \frac{Dose \cdot W_O}{TAR \cdot S_c}$ $\Rightarrow \frac{MU_O}{MU_W} = \frac{W_O \cdot WF \cdot WHF}{W_W}$

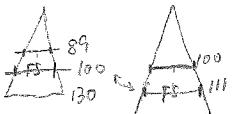
WHF $= PDD_W(d)/PDD_O(d)$ $\doteq 1$

2003.

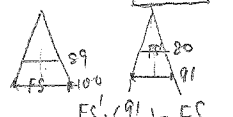
1. There are three hours to do the test. Questions #1-50 make up 40% of the grade. Questions #51-75 make up 60% of the test. You will have enough time to finish the test if your work fast.
2. How often do you have to re-measure the room shielding for HDR. during initial survey $\Rightarrow$ after source change
3. What happen in after the thyrotron fired? Klystron/magetron ; exeltron gun
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 $PDD = 100\left(\frac{f+dm}{f+d}\right)^2 e^{-\mu(d-dm)} \cdot KS$
5. Three 10 mg Ra-Eq each Cs sources in a straight line. The active and non-active lengths are given. Point A is 2cm from center source. Point b is 2 cm from the first source. What is the exposure ratio of at B to A? See picture below $= 100\times\left(\frac{100+2}{100+5.5}\right)^2 e^{-0.018(5.5-2)}$ $= 87.8\%$.
6. B (2cm) A
7. What is the best device for IVBT source calibration? $\Rightarrow$ { film $\rightarrow$ dose distribution; catheter based γ source $\rightarrow$ free air ion chamber; catheter based β source $\rightarrow$ well-type ion chamber; radioactive stent $\rightarrow$ extrapolation chamber; relative calib using well-type chamber } TG60
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 arterial, 2mm beyond the average lumen radius
9. Given Field AP-PA 10.4cm and Sup-Inf 16.8 cm with SAD setup, find the table kick angle to remove the beam divergent.
10. Given source size 3cm, SSD of 100cm, depth of 10cm and SDD of 30cm, Calculate the physical penumbra. $Pen = S\cdot\frac{SSD+d-SDD}{SDD} = 3\times\frac{100+10-30}{30} = 8cm$
11. A point is 2 cm outside of a 10x10 treatment field at 10cm depth, what % of dose does it get? $D_2 = \frac{1}{BSF(10\times10)}\times\frac{1}{2}\left[BSF(24\times10)\cdot PDD(24\times10,10) - BSF(4\times10)\times PDD(4\times10,10)\right]$ 5-10%



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) x 111

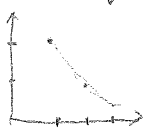


13. Patient was treated with 100 cm SAD setup with thickness separation of 22 cm. Patient is moved to cobalt with 80 cm SSD setup. What is the new field side?



FS' $\cdot\left(\frac{91}{80}\right) = FS$

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, 10R/mA-s. What is the dose rate at 2cm depth (Pdd= 0.6, BSF=1.15, fmed=0.9)

① $\left(\frac{f+dm}{f+dm}\right)^2 = \frac{100}{44}$ $\quad \left(\frac{f+dm+40}{f+dm}\right)^2 = \frac{100}{25}$ $\quad f+dm = 39cm$.

$D = (R_{fs}\cdot f_{med})\cdot BSF\cdot PDD$ (R_{fs}: Dmax)

$= (10R/mA\cdot s\cdot 0.96cGy/R)\cdot 1.15\times 0.6$

$= 6.21\ cGy/mA\cdot s$

{ daily 3%; monthly 2% }

TMR:

$D_{mp} = (DR\cdot mu)_{ref}\cdot TMR(d=9)$

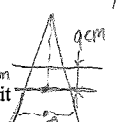
$D_{EXIT} = (DR\cdot mu)_{ref}\cdot\left(\frac{100}{100+9}\right)^2\cdot TMR(d=18)$

$\therefore D_{EXIT} = \frac{D_{MP}}{TMR(d=9)}\cdot TMR(d=18)\cdot\left(\frac{100}{100+9}\right)^2$

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.



Assume separation = 18cm. $D_E/D_{dm} = PDD(d=18)$ $\quad D_{mp}/D_{dm} = PDD(f=91, d=9)$.

19. How much charge would you get for a given exposure rate and chamber size, info given: 1R=2.58e-4 C/Kg, air density = 1.293e-3 Kg/cm2, chamber size = 0.19 cm3. $Q = X\cdot m \Rightarrow X(R)\ 2.58\times10^{-4}\ C/kg\cdot 1.293\ e^{-3}\ kg/cm^3\cdot 0.19cm^3$ $= $

$D_E = \frac{PDD(f=91,d=18)\cdot D_{mp}}{PDD(f=91,d=9)}$

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? $> 1mR/hr$
21. Patient treated with 3 fields, equally weighted, 180cGy. Two posterior fields go through 9 cm of lung and SSD is 82 cm. If you don't correct for lung inhomogeneity, what is the percent error at isocenter? overdose

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 ?

$MU_1 = \frac{60cGy}{(DR_{ref})\cdot S_c\cdot S_p\cdot TMR(18)}$ $\quad MU_2 = \frac{60}{D_{mp}\cdot S_c\cdot S_p\cdot TMR(9+9\times0.33)}$

$\Rightarrow \frac{MU_1}{MU_2} = \frac{TMR(9+9\times0.33)}{TMR(18)}$

A few beam spoiler questions to assure adequate dose to shallower target

23. For treating breast tangents- sometime 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 dmax to surface
25. Given aluminum and water mass and electron density, determine how thick the aluminum compensator should be to compensate 5 cm of tissue. Info given: Water: 3.2e23 e/g, 1g/cc, Al: 2.9e23e/g, 2.7 g/cc. $\Rightarrow t_0 = \left(\frac{TD}{\rho_{AL}}\right)\cdot\tau$ ($\tau \rightarrow 0.7$)
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… head leakage $= \frac{5cm}{2.7g/cm^3}\times 0.7$ $= 1.30cm$
27. TG 40, how often do you check electron output? monthly 2%.
28. TG 21 and TG 51, what is the % different in measurement and which is higher, lower, or the same? TG51 1% higher photon 2% higher electron

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 = 2xsigma/mu) $N = 2500$

2. Classic Ctrue, Cobs, 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)? 14

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) $\sqrt{1 - e^{-\lambda t}} = 0.8$.

$\Sigma \phi N t = (\lambda 10)$ sec.

5. Cromium 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… $B/A = 0.106$

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

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

10. P31 1.71Mev gamma ray (given). Best shielding material is → 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. 1mSv, B. 5mSv C….higher doses. public

12. Physicist does 50 brachy patients per year. Max dose allowed (per NCRP 116) to ring badge per patient is? $50\ \text{rem}/\text{yr}/50 =$ $500\text{mSv}/50 = 10\text{mSv}$

13. KM auger electron energy given KLM energies (need to know Aug. e emitted from shell where transitioning electron orginates) $E_{1s} \leftarrow 2\ E_M$

14. Electron Anode to cathode time? Given voltage and distance. No mass of electron given. A fast solution involves calculating the final γ (=1/(1-vf2/c2)**1/2). Solve for Vfinal, assume Vaverage = Vf/2 (OK if only few 100 keV), then get time from distance.

$eV = \frac{1}{2} m v_f^2$

$= \frac{1}{2}(m_e c^2)(\beta)$

$V t/2 \cdot t = L$.

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

$E = \gamma m_0 c^2 = \frac{1}{\sqrt{1-\beta^2}} \cdot 0.51 = 1.17\ \text{MeV}$.

$\frac{1}{\sqrt{1-v^2}}$

16. Electron accelerated through 4MV, what velocity? Fast solution again uses γ → 0.994c

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

18. Unit vectors j X i (ie j cross i) = …… -k.

19. Length of 1i +1j+1k √3

20. Neutron of velocity XXXX hits and is captured by 59Co nucleus. Before 60Co decays, what is the velocity of the 60Co nucleus (I applied simple cons of momentum) $v' = \frac{m_0 v}{m_{60}}$

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. $4e^{-\mu_L x} / e^{-\mu_H x}$

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

23. Γ = 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. $\Gamma = 13.8 \Sigma (k_i E_i \frac{\rho}{r^2})$ 1.5 x 1.5 → 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 1/9th 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. $\int_{0.1Em}^{Em}$ (Em-E)dE. Evaluate the definite integral in terms of Em. 0.405 Em^2 Constant

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. $KE = \frac{1}{2} I\omega^2$

34. A Petabyte is ???? x 10^{12} bytes → $10^{15} \rightarrow 2^{20}$
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". 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. sensitivity 1 − specificity

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 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 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 4. $\propto I^2 R$

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. 1mm B 5mm ….

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

30. Given an isotope with a know half-life, how long does it take to give 95% of total dose. D_{total} $D = \dot{D} \cdot T_{irrad}(1-e^{-\lambda t}) = \dot{D}(1.44 T_{1/2})(1-e^{-\frac{\ln 2}{T_{1/2}} t}) \Rightarrow 0.95 = (1-e^{-\frac{\ln 2}{T_{1/2}} t})$

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. $\dot{D} T_{irrad} = 500 mRem$

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. 3% → electron.

34. You are 50 meter above the airport, what % change do you expect to see in pressure? 0.6% $P = P_0 \cdot e^{-0.000125 \times 50} = 0.994 P_0$

35. Given an AP and a Lat film with two points identified, find the distance between them. $\sqrt{(x_1-x_2)^2+(y_1-y_2)^2+(z_1-z_2)^2}$ or length projections

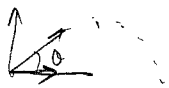
Part 1 of the ABR exam 2003

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 $\sqrt{n \cdot p(1-p)}$.
2. A question on a proton traveling at a certain velocity and collideing 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 $1.11 \times 10^{-17} kg$
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. $P = \sqrt{2} \, rms$
6. Given a sound with a certain frequency if you are traveling so fast towards it what frequency do you hear $\left(\frac{V}{V-V_s}\right) \cdot f_s$.
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 a 1024 matrix with 8 bits/pixel with a 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? $\begin{cases} 45 = m \times 0.6 \\ 45 + x = (m+x) 0.75 \end{cases}$
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. 31.5 km
12. Which laser would not be used for fiber optic communication? HeNe, YAG, ~~CO_2~~ 10 μm surgery.
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 B over the same time 4.
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. Neutron activation.
16. Neutron loses 0.5 of energy per collision. How many collisions to lose x energy?

11. $v \times \cos\theta$ $v \times \sin\theta$ $v_0/\sqrt{2} = gt \Rightarrow t = \frac{2 \cdot V_0}{\sqrt{2} g} = \frac{\sqrt{2} V_0}{g}$.



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? 150°

Clinical Section:

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?
3. A question about dysplasia ← neoplasma
4. Where are the islets of Langerhans 胰岛
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_0, D_1, D_t, extrapolation number.
9. Given a list of bones, name which one is in the lower leg.

10. Given list, which is not a bone of the upper extremities?
11. Where is CSF made? choroid plexus
12. Where do you find the glomerulus?
13. what is the function of the alveoli?
14. What is the most radiosensitive part of the eye? lens
15. What fluid lubricates the joints synovial
16. What is the dose needed to cause skin erythema? 3/2 Gy
17. Dose limits. Dose to double cancer rate. 5 Gy 1 Gy mutation
18. Dose vs. effect in embryo
19. Average effective background at sea level including Ra α. 2 mSv ?
20. Which organ absorbs the most water? small intestine ? ✓ ↓ diffussion
21. Which is the most sensitive organ given a list.

8% / per Gy × 3 = 24%

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 L4-5 (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. 2-56 days (8-14days) ?

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

10. Irradiation in the first week following conception results in …. Intrauterine death, leukemia in the child, mental retardation, congenital abnormailties …..

11. Irradiation in late stages of pregnancy results in …. Intrauterine death, leukemia in the child, mental retardation, congenital abnormailties …..

(8-15 week) (2-8 week)

12. A patient has reacted to contrast. This would most likely be from barium, iodine, (15%) 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

@ IVC

24mSv

灌肠

10mSv

14. The peritioneum is in the A. Abdomen, B. Brain, C. Thorax. ….

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

① KUB
frontal supine radiography
0.9mSv kidney, Bladder, Ureters
check GI condition { bowell obstruction, gall stones, kidny stones, ureteric stents

② X-ray exam larger bile ducts within liver and outside
IVC

③ IVP (intravenous pyelogram)
radiographic procedure to investigate pathology of kidney, Bladder, urinary system.
25mSv

16. Blood leaves left ventricle into what? Aorta

17. Systole Volume = 36cc, Diastole volume = 91cc. What is the ejection fraction of the heart. 收缩 舒张 (LV) (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.
this > 3.5 Gy

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. fix DNA damage (fixation)

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

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. brain stem.

26. The master hormone gland is the: Pituitary

27. Most stable product of hydrolysis(?) radiolysis (?) of water is:
A. OHdot B. Hdot C. H2O D. H2O2 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. ↑ insulin due to excessive dose
Not glucagon !!!

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

glycogen 糖原
glucogen

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 .... 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 L 2 R 3

50. Artery to the liver hepatic

51. Number of temporal lobes in the brain 2

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

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.

1. A B C
1 2 3

$D_A = D_{1a} + D_{2a} + D_{3A}$
$= DR \cdot T_1 + DR \cdot T_2 (\frac{1}{\sqrt{2}})^2 + DR \cdot (\frac{1}{\sqrt{3}})^2 \cdot T_3$
$= 1.2 \cdot DR \cdot T_1 + \frac{1}{2} DR\, T_2$

$D_A = D_B$
$\Rightarrow 1.2\,DR \cdot T_1 + 0.5\,DR \cdot T_2 = DR\,T_1 + DR\,T_2$
$\Rightarrow 0.2\,T_1 = 0.5\,T_2$
$\Rightarrow T_1 = 2.5\,T_2$

$D_B = D_{1B} + D_{2B} + D_{3B} = DR \cdot T_1 (\frac{1}{\sqrt{2}})^2 + DR\,T_2 + DR \cdot T_1 (\frac{1}{\sqrt{2}})^2$
$= DR \cdot T_1 + DR\,T_2$

2004 ABR Therapy Part 2, Written.

1. HDR, three dwell positions (1, 2 and 3 – 2 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 A equal dose B.

$P_{pol} = \left| \frac{M_{raw} - M_{raw}}{2 M_{raw}} \right|$

2. TG51 question (no TG21 in whole exam). Given Ppol, Pelec, T (deg C), P (mmHg), Vhigh = +300V, Vlow = +150V, 100mu Reading for Vh = 1.71 …., 100mu reading for Vl = 1.70…., given 60CoNdw Gy/C for chamber, given pdd photon, given kQ (not asked to do energy determination to find kQ) calc cGy/mu at dmax for photon beam. Answers approx 0.6% apart. (Also given plenty of irrelevant information such as TG51 electron beam parameters)

$P_{ion} = \frac{1 - V_H/V_L}{M^+/M^- - V_H/V_L}$
$P_{TP} = \frac{273.2+T}{295.2} \times \frac{760}{P}$
$M = P_{ion} \cdot P_{pol} \cdot P_{elec} \cdot P_{TP} \cdot M_H$
$D_w^Q = M \cdot k_Q \cdot N_{D,w}^{60Co}$ @ 10cm. $D_{w,Q,dm}^Q = D_w^Q / PDD(d=10)$ or TMR

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 profession not 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.

$K_{unR} = \frac{P \cdot d^2}{WU \cdot T}$ [8x0.305² m²]
$= \frac{(0.002 R/wk) \cdot [12ft - 48" + 1m]^2}{(800 mA.min/wk) \times \frac{1}{4} \times 1}$
$= 1.18 \times 10^{-4}$ R/mA.min

4. AP/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? Cord dose = 62+150×0.18 = 89 cGy
→ should provide more info. Gobj/30fx to tumor
fx = 4000/89 = 45
$\begin{cases} 89x + 212y = 4000 \\ x + y = 30 fx \end{cases} \Rightarrow \begin{cases} x = 19 \\ y = 11 \end{cases}$ (4.69)

5. Counts given (cpm) for reference source with known activity (mCi). How many counts allowed to stay below wipe test leakage limit – limit not given (5nCi?).
efficiency = $\frac{x(cpm)}{y(mCi)}$ ∈ (5nCi)
$5(nCi) \times \frac{x(cpm)}{y(mCi)}$ =

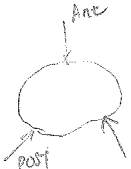
6. 2cm diameter lead pig inside polyurethane foam inside 30cm diameter shipping drum. HVL Pb given. Exposure rate constant of 192 Ir given (but not the one I know!). Calc max activity to keep below 50mR/hr on surface. Another variant of this question used 137Cs (again I didn't recognize the exposure rate constant provided), activity provided and asked to calc thickness of lead to reduce exposure rate to certain level (TVL given).
$A(mCi) \cdot \Gamma \cdot (R \cdot cm^2/hr \cdot mCi) \cdot (\frac{1}{2})^{\#TVL} \cdot (\frac{1}{30cm})^2$
$= 0.05$ R/hr

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

8. TBI, diode reading 450cGy on surface, presc midline 600cGy POP laterals, 30cm separation. TMR's given, 350cmSSD. 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 fluorescent screen → liquid ion chamber, solid state detectors (silicon diodes), zinc tungstate scintillating, Amorphous silicon (a-Si)
mirror → replace by fiberoptics system
CCD/video camera

Light/Rad field coincidence 2mm or 1% on a side, which ever is greater.



d=15cm.
$d_{eff} = 15 - 9 + 9 \times 0.33 = 8.97$cm.
$MU_{ant} = \frac{D_{rd}}{DR \cdot TMR(d=15)}$
$MU_{post} = \frac{D_{rd}}{DR \cdot TMR(d=8.97)}$
$\frac{MU_{ant}}{MU_{post}} = \frac{TMR(d=9)}{TMR(d=15)} > 1$
$= \frac{0.8}{0.639}$

9. Three beams 120 deg apart, AP and post obliques. 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. $(\frac{1}{3} D_{max}) / D_{d,m} = PDD$
13. Neutron dose equivalent (mSv) outside field per photon Gy at isocenter.
14. Neutron dose equivalent ratio 18MV vs 15 MV. Answers were fairly widely separated ie 1, 2, 5, 10, 100. (per cGy)? mSv/Gy 1~2

15. Given distance iso to maze and maze length, neutron dose at iso (mSv) per photon cGy at iso, 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. $H_1 = H_0 (mSv/Gy) \cdot \frac{S_0}{S_1} \cdot (\frac{d_0}{d_1})^2 \cdot (\frac{1}{10})^{d_2/5}$

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

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
dual scatter only for high E electron

18. g(r) for 125I vs 103Pd. A. same at all depths, B. Pd exceeds I beyond 1cm, C Pd exceeds I beyond 4cm, D. I 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. ⇒ 3%

22. TG 40 photon flatness spec. Electron X-ray beam flatness constancy ⇒ 2%

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….

25. TBI – what is not true – A. Dose Uniformity < 15% B. Tissue Equivalent compensators are used C. High SSD D. AP preferred over lateral.
Dose uniformity ~ 10%
High E preferred.
well ionchamber leakage Redundant check } F. { 2% D
all other test ⇒ I.
linearity ⇒ 1.2 years
0.1% → For both local standard and field instruments leakage, collecting potential should be checked Each use. Table IV.

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. $S/\rho \cdot \rho = S \Rightarrow$ MeV/cm $\left(\frac{18\text{MeV}}{S}\right) =$ cm

28. HDR 192Ir. Patient treated with time XXX with Activity YYY on Aug 15th. Source replaced with activity ZZZ on Aug 17th. Treatment time on Aug 22nd is ? No 192Ir half life given. 1% decay per day. tx on Aug 17th $= (YYY/ZZZ)\cdot XXX$. tx on Aug 22nd $= (YYY/ZZZ)\cdot XXX \cdot e^{\frac{5}{T_{1/2}}\ln 2} = \left(\frac{YYY}{ZZZ}\right) XXX \cdot 1.048$

29. Nothing on TBElectron

30. 10MV through 6cm lung, dose actual vs dose without inhomogeneity. No other data given. Increase of dose beyond lung. ^{60}Co 4%/cm 4MV 3%/cm 6MV: 10MV: 2%/cm 25MV: 1%/cm

31. A question involving 10mg Ra – simple application of ΓxA/d2 – but needed to know (ie not given) exposure rate const. = 8.25 Rcm2/mg.hr

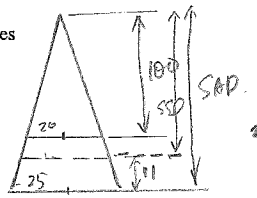
32. Shielding question. 36 in space available for needed 6 TVL (this information was given). Pb TVL given. Concrete TVL given. What is the minimum thickness of Pb needed.

33. How many TVL's in a linac head. 0.1% ⇒ 3 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)



SAD = 100X $\frac{25}{20}$ = 125

SSD = SAD − 11 = 125 − 11

= 114

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. $120 \times \frac{140}{102} = 165$ cm.
magnification: (140/102) 10x10 field ⇒ 13.7@ film

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 at 13.7cm @ SFD ⇒ SFD = 165cm

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

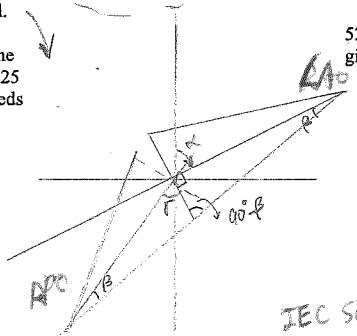
40. I'm vague on this one but I'll give it to you anyway. The question went like …. The simulator couch wouldn't go low enough, so the film was taken at X SSD, separation 25 cm, distance to film = 140 cm. Physician wants to treat at 132 SSD, simulator film needs to be placed at what distance to cut blocks.

Assume SAD TX

$mag = \frac{140}{X+12.5} \Rightarrow SFD = \frac{140}{X+12.5} \times (132+12.5)$

$mag = \frac{SFD}{132+12.5}$

or SSD+X: $mag = \frac{140}{X} \Rightarrow SFD = \left(\frac{140}{X} \cdot 132\right)$



$\gamma + \beta = 90 - \beta$

$\gamma = 90 - 2\beta$

$G_2 = \alpha + 90° + \gamma$

$= \alpha + 90 + 90 - 2\beta$

$= 120 + \alpha - 2\beta$

$\beta = \arctan\left(\frac{F}{2X100}\right) = \arctan\left(\frac{10.5}{200}\right)$

$\alpha = 45°$

IEC Scale

$\Rightarrow G_2 = 218.9° \Rightarrow 360° - G_2$

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

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 ⇒ high Energy

43. Beam steering vs gantry angle in a linac. Signals to steer originate from ….. ion chamber …. various other options. transmission ion chamber ⇒ { monitor dose rate & integral dose; angular and radial distribution of radiation beam.

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. ↓ normalized. relative measurement.

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. Bremstrahlung B. Output Factor, C. Depth of 80%, D. Surface Dose. (R_p) ↑

bremsstrahlung interaction { scattering foil, chamber, collimator jaws

47. I50 ionization depth of an electron beam is 5.1 cm. The energy of the beam is ….. ↓ ↓ ↳ if FS < lateral scatter equilibrium. PDD change, dose shift toward surface

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

$R_{50} = E/2.33$

$R_{50} = 1.09 T_{20-80} - 0.06$ 0.06

$= 4.647 - 5.188$

$E = 4.647 \times 2.33$

$= 12.08$ MeV

12.08

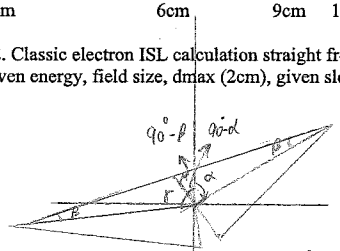
49. A survey points a linac beam at a primary wall and measures 2mR/hr. Is this OK? There were various options in the answers, but this was the point of the question.

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.

0cm	6cm	9cm	10cm
	Block		

52. Classic electron ISL calculation straight from Kahn, ie calculate the effective SSD, given energy, field size, dmax (2cm), given slope of $(Io/Ig)^{1/2} = 0.0111$. → effective SSD.



dose with zero gap

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

↓

dose with gap g between standard SSD and surface.

$\gamma = 90° - 2\beta$

$G_2 = 360° - [(90° - \alpha) + \gamma]$

$= 360° - [90° - \alpha + 90° - 2\beta]$

$= 180° + \alpha + 2\beta$

$\frac{\ln 10}{TVL} = \frac{\ln 2}{HVL} = \frac{\ln 5}{FVL}$ ...

$\left(\frac{100}{52.3}\right) = \left(\frac{f+10}{f}\right)^2 \Rightarrow 26\,cm$.

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 →

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 (cGy) and had to calculate roentgens (R) from this. I think you just divide by 0.876 rad/R – this gave one of the answers.

57. Dose to cord from AP/PA 100 SAD setup. 22cm separation, cord 4cm deep, 200cGy to isocenter. TMRs given.

$\frac{1}{2}D_{mp} = DR \cdot MU \cdot TMR(d=11)$

$D_{cord} = DR \cdot MU \cdot \left(\frac{100}{104}\right)^2 \cdot TMR(d=4)$

$D_{cord} = DR\,MU \left(\frac{100}{100+7}\right)^2 \cdot TMR(d=18)$

89cm, 11cm, 200cGy, 4cm, 11

58. Most radiation sensitive part of the eye is ..... lens

59. TVL is related to HVL by A: TVL = ln10/ln2 HVL, B… other impressive but erroneous relationships.
This rule and it's generalization can be used to speed up all sorts of calcs, not just in shielding but with regard to time as well – use it!

$\left(\frac{1}{10}\right)^{\frac{X}{TVL}} = \left(\frac{1}{2}\right)^{\frac{X}{HVL}}$

$\frac{X}{TVL}\ln\left(\frac{1}{10}\right) = \frac{X}{HVL}\ln\left(\frac{1}{2}\right)$

$\frac{TVL}{HVL} = \frac{\ln\left(\frac{1}{10}\right)}{\ln\left(\frac{1}{2}\right)}$

$TVL = \frac{-\ln 10}{-\ln 2} \cdot HVL = \frac{\ln 10}{\ln 2} HVL$

$= \frac{2.303}{0.693} HVL = 3.32\,HVL$

Net OD (linear scale) vs log exp / Dose

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.

$OD = \log\frac{I_0}{I_t} = \log 200 = 2.3$

general radiograph

61. Electrons at extended SSD, which is true?
A. Width of the 90% extends proportionately B. Penumbra increases C. Output follows 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).
(15cm, 20cm) > lateral scatter equilibrium ⇒ field equivalence ⇒ the same PDD along CAX but different output factors.
↓
no change in surface dose (%)
↓
relatively !!
If assume FS 15→20cm and no MU change
- output ↑. D_{dm} ↑.
- % skin dose →
- abs skin dose ↑.

For radiochromic film OD is also in log scale!

63. Why does the equivalent square technique work? A. Because scatter doses are equal between square and rectangular fields, 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_L + 1HVL, B other options including Ts + T_L, Ts + 1TVL. (T_L or Ts which is greater) + 1HVL

65. Order of materials in door for high energy linac – inside to outside.
lead + BPE + lead

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

E backscatter ↗ with Z↑
↘ with E↑

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. ⇒ leakage 0.1%, redundancy D, collecting potential D

69. Classic isocentric POP 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/mu 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 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. $D = (DR \cdot T) \cdot BSF \cdot PDD \cdot \left(\frac{SCD}{T+10cm}\right)^2$

71. Had to do single field 125 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. $D = DR \cdot MU \cdot Sp \cdot Sc \cdot \left(\frac{100}{125+dm}\right)^2$
↳ in water?

72. Multiple beam plan. AP weighted to 100% at dmax, laterals weighted to 100% at dmax. 200 cGy delivered to 238% isodose line. Dose delivered by AP beam is ??? cGy. · PDD (F)
200 / 238% = 84.0cGy → 100% dose → AP 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.

74. Dose 10cm deep 5cm outside field is (A) 1% B. (2%) C. 3% D. 4% E. 5% (high E ↑ → ⁶⁰Co; under block 20%; For ⁶⁰Co Exp 7. in Kahn's book)

75. Γ factors given on several questions were not what I expected for the isotope in question. But I always used the one given.

76. Pacemaker dose limit. ⇒ TG34 2Gy. if total dose > 2Gy. pacer maker function should be checked 2Gy-10Gy

77. Apparent mCi is (less) / more / same as mCi → encapsulation effect

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%
e beam flatness constancy: 3%

X ray + e^- : Symmetric 3%

2004 Part 1Writtens

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 ~1.7Mbits/sec, how many minutes for the transfer? (You'd have to know the standard bit depth of a CT image). 4.1 m → 5.88 min

2. A terabyte is equivalent to:
a. 10E4
b. 10E5
c. 10E6 10^{12}
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

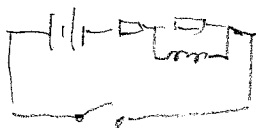
5. If a sample has 1600 total counts in 4 minutes and the background has 900 total counts in 3 minutes, the activity of the sample is 100 +/- 14 cpm.

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? N=50 N=2500

There was one circuit:

7. 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 → ∞? 0

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? $Y = 2t - e^t$ ln 2

There were a few questions on ultrasound, such as: crystal

9. Ultrasound transducers transmit and receive pulses using what effect? piezoelectric

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

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? 20

17. If a patient is 8 HVLs thick, what's the ratio of entrance exposure to exposure at midpoint? 10

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? $\frac{4 \cdot e^{-\mu_L 20}}{e^{-\mu_H 20}}$

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/wk. What's the overall exposure rate to the secretary in mR/wk?

There were several dosimeter-type questions, such as:

21. 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 μs, 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, such as:

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?

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

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?

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?

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 _____.
3. The background dose excluding radon at sea level is _____ mSv/hr.
4. Dose risk estimates are based on the _____, _____ dose effects 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 sagital 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, vena cava, trachea in various combinations
10. Where does filtered lymph reenter the bloodstream?
11. What produces estrogen?
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)
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16. What is fibromyosis associated with?

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 .... 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 L 2 R 3

50. Artery to the liver hepatic

51. Number of temporal lobes in the brain 2

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

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%

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 L4-5 (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. 8-56 days (8-14days) ?

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

10. Irradiation in the first week following conception results in …. Intrauterine death, leukemia in the child, mental retardation, congenital abnormailties …..

11. Irradiation in late stages of pregnancy results in …. Intrauterine death, leukemia in the child, mental retardation, congenital abnormailties …..

12. A patient has reacted to contrast. This would most likely be from barium, iodine, 1.5 g/o. 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

16. Blood leaves left ventricle into what? Aorta

17. Systole Volume = 36cc, Diastole volume = 91cc. What is the ejection fraction of the heart. (LV) (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.
> 3.5 Gy

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. fix DNA damage (fixation)

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. brain stem.

26. The master hormone gland is the: Pituitary

27. Most stable product of hydrolysis(?) radiolysis (?) of water is:
A. OHdot B. Hdot C. H2O D. H2O2 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. ↑ insulin due to excessive dose Not glucagon !!!

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

KUB
frontal supine radiography
.9mSv
Kidney, Bladder, Ureters
check GI condition { bowell obstruction, gall stones, kidny stones, ureteic stents

10mSv

IVC

24mSv

灌肠

IVC
X-ray exam larger bile ducts within liver and outside

IVP (intravenous pyelogram)
radiographic procedure to investigate pathology of kidney, Bladder, urinary system.
2.5mSv

glycogen 糖元
glucogen

16. Electron accelerated through 4MV, what velocity? Fast solution again uses γ → 0.994c

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

18. Unit vectors j X i (ie j cross i) = …… -k.

19. Length of 1i +1j+1k $\sqrt{3}$

20. Neutron of velocity XXXX hits and is captured by 59Co nucleus. Before 60Co decays, what is the velocity of the 60Co nucleus (I applied simple cons of momentum) $V' = \frac{m_0 V}{m_{Co}}$

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. $4e^{-\mu_L x} / e^{-\mu_H x}$

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

23. Γ = 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. $\Gamma = 13.8\Sigma(k_i E_i (\frac{n}{p}))$ 1.5 x 1.5 → 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 1/9th 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. $\int_{0.1Em}^{Em} (Em-E)dE$. Evaluate the definite integral in terms of Em. $0.405 Em^3$ Constant

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. $KE = \frac{1}{2} I\omega^2$

34. A Petabyte is ???? x 10^{12} bytes → $10^{15} \rightarrow 2^{20}$
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". 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. sensitivity, 1 - specificity.

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 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 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 4. $\propto I^2 R L$

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. 1mm 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 = 2xsigma/mu) $N = 2500$

2. Classic Ctrue, Cobs, 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)? 14

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) $2\phi N t = (\lambda N)_{sat}$. $1 - e^{-\lambda t} = 0.8$.

5. Cromium 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… $B/A = 0.106$

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

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

10. P31 1.71Mev gamma ray (given). Best shielding material is → 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. 1mSv, B. 5mSv C….higher doses. public

12. Physicist does 50 brachy patients per year. Max dose allowed (per NCRP 116) to ring badge per patient is? 50 rem/yr / 50 = 500mSv/50 = 10mSv

13. KM auger electron energy given KLM energies (need to know Aug. e emitted from shell where transitioning electron orginates) $E_{1s} \leftarrow 2E_M$

14. Electron Anode to cathode time? Given voltage and distance. No mass of electron given. A fast solution involves calculating the final γ (=1/(1-vf2/c2)**1/2). Solve for Vfinal, assume Vaverage = Vf/2 (OK if only few 100 keV), then get time from distance. $eV = \frac{1}{2}mv^2$ $= \frac{1}{2}(m_0c^2)(\beta^2)$ $Vt/2 \cdot t = L$.

15. Electron 0.9c, what is the total mass / energy in MeV. Given mo = 0.51 MeV.
$E = \gamma m_0 c^2 = \frac{1}{\sqrt{1-\beta^2}} \cdot 0.51 = 1.17\ MeV$.

$\frac{1}{\sqrt{1-\beta^2}}$.

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? 150°

Clinical Section:

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?
3. A question about dysplasia ⇐ neoplasma
4. Where are the islets of Langerhans 胰島
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_0, D_1, D_t, extrapolation number.
9. Given a list of bones, name which one is in the lower leg.

10. Given list, which is not a bone of the upper extremities?
11. Where is CSF made? choroid plexus
12. Where do you find the glomerulus?
13. what is the function of the alveoli?
14. What is the most radiosensitive part of the eye? lens
15. What fluid lubricates the joints sjouint
16. What is the dose needed to cause skin erythema? 3/2 Gy
17. Dose limits. Dose to double cancer rate. 5 Gy 1 Gy mutation
18. Dose vs. effect in embryo
19. Average effective background at sea level including Ra a. 2 mSv ?
20. Which organ absorbs the most water? small intestine ? ✓
21. Which is the most sensitive organ given a list. diffusion

8% / per Gy × 3 = 24%

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

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

$$D = \dot{D} \cdot T_{Avg}(1 - e^{-\lambda t}) = \dot{D}(1.44 T_{1/2})(1 - e^{-\frac{\ln 2}{T_{1/2}} t}) \Rightarrow 0.95 = (1 - e^{\frac{\ln 2}{T_{1/2}} t})$$

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.

$\dot{D} T_{avg} = 500 mRem$

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

33. TG 40, what % is the flatness of the beam should be? 2% → photon. 3% → electron

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

$$P = P_0 \cdot e^{-0.000125 \times 50} = 0.994 P_0$$

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

$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$ 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 $\sqrt{n \cdot p(1-p)}$.
2. A question on a proton traveling at a certain velocity and collideing 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 $1.11 \times 10^{-17} kg$
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. $P = \sqrt{2} rms$
6. Given a sound with a certain frequency if you are traveling so fast towards it what frequency do you hear $\left(\frac{V}{V - V_s}\right) \cdot f_s$.
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 a 1024 matrix with 8 bits/pixel with a 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?

$$\begin{cases} 45 = m \times 0.6 \\ 45 + x = (m + x) \cdot 0.75 \end{cases}$$

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. 31.5 km
12. Which laser would not be used for fiber optic communication? HeNe, YAG, CO_2? 10 μm. surgery.
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 B over the same time 4.
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. Neutron activation.
16. Neutron loses 0.5 of energy per collision. How many collisions to lose x energy?

11. $v \times \cos\theta$. $v \times \sin\theta$ $v_0/\sqrt{2} = gt \Rightarrow t = \frac{2 \cdot V_0}{\sqrt{2} g} = \frac{\sqrt{2} V_0}{g}$.

22. Dose weighting between open and wedge fields: $W_O + W_W = 1$

$W_W = \frac{\tan\theta_{eff}}{\tan\theta}$ $\quad W_O = 1 - W_W$

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

② $MU_W = \frac{DOSE \cdot W_W}{TAR \cdot S_c \cdot WF(WHF)}$ $\quad MU_O = \frac{DOSR\ W_O}{TAR \cdot S_c}$ $\Rightarrow \frac{MU_O}{MU_W} = \frac{W_O \cdot WF \cdot WHF}{W_W}$

WHF $= PDD_W(d)/PDD_O(d) \doteq 1$

2003.

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 your work fast.
2. How often do you have to re-measure the room shielding for HDR. during initial survey → after source change
3. What happen in after the thyratron fired? Kylstron/magetron ; enefron gun
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

$PDD = 100 \left(\frac{ftdm}{ftd}\right)^2 e^{-u(d-dm)} \cdot Ks$

5. Three 10 mg Ra-Eq each Cs sources in a straight line. The active and non-active lengths are given. Point A is 2cm from center source. Point b is 2 cm from the first source. What is the exposure ratio of at B to A? See picture below

need confirm ←

$= 100 \times \left(\frac{100+2}{100+5.5}\right)^2 e^{-0.018(5.5-2)}$

$= 87.8\%$.

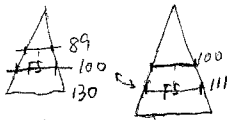
6. |2cm B | A

7. What is the best device for IVBT source calibration? ⇒ film → dose distribution; catheter based γ source → free air ion chamber / well-type ion chamber; catheter based β source → extrapolation chamber; radioactive stent → relative calib using well-type chamber TG60
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 arterial, 2mm beyond the average lumen radius.
9. Given Field AP-PA 10.4cm and Sup-Inf 16.8 cm with SAD setup, find the table kick angle to remove the beam divergent.
10. Given source size 3cm, SSD of 100cm, depth of 10cm and SDD of 30cm, Calculate the physical penumbra.

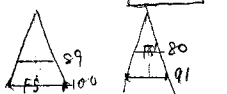
$P_{enw} = S \cdot \frac{SSD+d-SDD}{SSD} = 3 \times \frac{100+10-30}{30} = 8cm$

10 2 2 10 / 10 / 10

11. A point is 2 cm outside of a 10x10 treatment field at 10cm depth, what % of dose does it get? $D_2 = \frac{BSF(10\times10)}{2}\left[BSF(24\times10)\cdot PDD(24\times10,10) - BSF(4\times10)\times PDD(4\times10,10)\right]$ 5~10%
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) x 111

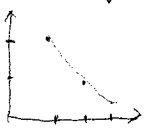


13. Patient was treated with 100 cm SAD setup with thickness separation of 22 cm. Patient is moved to cobalt with 80 cm SSD setup. What is the new field side?



$FS' \cdot (\frac{91}{80}) = FS$

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, 10R/mA-s. What is the dose rate at 2cm depth (Pdd= 0.6, BSF=1.15, fmed=0.9)



① $\left(\frac{ftdm+20}{ftdm}\right)^2 = \frac{100}{44}$

$\left(\frac{ftdm+40}{ftdm}\right)^2 = \frac{100}{25}$

$ftdm = 39cm$.

$D = (R_{fs} \cdot f_{med}) \cdot BSF \cdot PDD$ (R_{fs}: D_{max})

$= (10R/mA\cdot s \cdot 0.9 cGy/R) \cdot 1.15 \times 0.6$

$= 6.21\ cGy/mA\cdot s$

{ daily 3% / monthly 2%

TMR:

$D_{mp} = (DR\cdot mu)_{ref} \cdot TMR(d=9)$

$D_{EXIT} = (DR\cdot mu)_{ref} \cdot \left(\frac{100}{100+9}\right)^2 TMR(d=18)$

$\therefore D_{exit} = \frac{D_{mp}}{TMR(d=9)} \cdot TMR(d=18) \cdot \left(\frac{100}{100+9}\right)^2$

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.

Assume separation = 18cm. $D_E/D_{dm} = PDD(d=18)$ $\quad D_{mp}/D_{dm} = PDD(f=91, d=9)$

19. How much charge would you get for a given exposure rate and chamber size, info given: 1R=2.58e-4 C/Kg, air density = 1.293e-3 Kg/cm2, chamber size = 0.19 cm3. $Q = X\cdot m \Rightarrow X(R)\cdot 2.58\times10^{-4} C/kg \cdot 1.293 e^{-3} kg/cm^3 \cdot 0.19 cm^3$ =

$D_E = \frac{PDD(f=91,d=18)\cdot D_{dm}}{PDD(f=91,d=9)}$

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? > 1mR/hr

21. Patient treated with 3 fields, equally weighted, 180cGy. Two posterior fields go through 9 cm of lung and SSD is 82 cm. If you don't correct for lung inhomogeneity, what is the percent error at isocenter? over dose

$MU_1 = \frac{60 cGy}{(DR_{ref})S_c S_p \cdot TMR(}$

$MU_2 = \frac{60}{D_{ref}\cdot S_c S_p \cdot TMR(} \quad +9\times0.33)$

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 ?

$\Rightarrow \frac{MU_1}{MU_2} = \frac{TMR(9+9\times0.33}{TMR(9)}$

A few beam spoiler questions to assure adequate dose to shallower target

23. For treating breast tangents- sometime 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 dmax to surface
25. Given aluminum and water mass and electron density, determine how thick the aluminum compensator should be to compensate 5 cm of tissue. Info given: Water: 3.2e23 e/g, 1g/cc, Al: 2.9e23e/g, 2.7 g/cc. $\Rightarrow t_c = \left(\frac{TD}{\rho_{AL}}\right)\cdot T$ ↳ 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… head leakage

$= \frac{5cm}{2.7 g/cm^3} \times 0.7$

$= 1.30cm$

27. TG 40, how often do you check electron output? monthly 2%
28. TG 21 and TG 51, what is the % different in measurement and which is higher, lower, or the same? TG51 1% higher photon; 2% higher electron

$2^{\#6} = 64$

$\frac{512 \times 512 \times 6}{X}$ bit/s

Image of 512x512, gray scale of 64, info transmitted at X baut rate, how long does it take

Two batteries are connected in series through a resistor. One of them is flipped, what is the new current.

A 2 tesla MRI scan. The sample has a contamination of 10 ppm. What is the noise that is introduced.

Clinical:

Where is the foramen Magnum.

What is Meiosis

Where are the adrenal glands.

What makes the gall bladder contract. fat.

Flow of blood through heart.

How many cranial nervers are there 12

If a patient is dehydrated, the patient lacks ??? Sodium Na^+

What do you use a thallium scan for

What scan do for a Hiatal hernia barium x-ray endoscope gastroscope

Function of cerrebellum

Function of spleen

What connect the two cerebral hemispheres → corpus callosum ⇔ corpus luteum

Male chromosome are XY or XX

★ Graph of two survial curves, What is identical (Do, Dq, n, OER) 脊柱弯曲

Order of the small intestine duo – Ileum Jejunum

What causes portal hypertension liver sclerosis → cirrhosis 肝硬化

Which artey is the main blood supply for the liver portal.

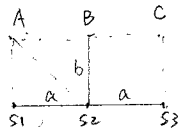
	prone			supine		
	RL	LL	PA	RL	LL	PA
Y_1	Y_{1b}	Y_{1b}		Y_{1b}	Y_{1b}	
Y_2			Y_{2S}			Y_{2S}
G	90°	270°	0°	270°	90°	180°
Coll	$\theta = \tan^{-1}(\frac{Y_{2S}}{100})$	$360° - \theta$	0	0	$360° - \theta$	0°
Couch	$360° - \alpha$	$\alpha = \tan^{-1}(\frac{Y_{1b}}{100})$	0	α	$360° - \alpha$	0°

toward gantry

G=270° Couch=90°

G=90° couch=270°

α 0 $360° - \alpha$



$D_A = A \cdot (\frac{1}{b})^2 + A(\frac{1}{a^2+b^2})^2 + A(\frac{1}{\sqrt{(a)^2+b^2}})^2 = A \cdot [\frac{1}{b^2} + \frac{1}{a^2+b^2} + \frac{1}{4a^2+b^2}]$

$D_B = A(\frac{1}{\sqrt{a^2+b^2}})^2 + A \cdot \frac{1}{b^2} + A \cdot (\frac{1}{\sqrt{a^2+b^2}})^2 = A \cdot [\frac{2}{a^2+b^2} + \frac{1}{b^2}]$

$D_A/D_B = \frac{1/b^2 + 1/a^2+b^2 + 1/4a^2+b^2}{2/a^2+b^2 + 1/b^2}$

2003

Part II, Therapy:

Lots of shielding questions

How often do you calibrate the barometer 3 month TG-40. 1mm/Hg

A concrete wall (66 inches) is to be replaced with a thinner wall (36 inches) consisting of concrete and steel. TVL of steel and concrete were given. Calculate the steel thickness.

Lots of MU calcs, SSD to SAD, Entrance-Exit dose, extended SSD. $\frac{66}{TVL} = \frac{X}{TVL} + \frac{Y}{TVL}$, $X+Y=36$

TG-51: for photon calibration, above how many MV do you have to use how thick a layer of lead at how many cm from the source? 10. 1mm. 50±5cm

How much difference will the calibration be by using TG 21 and TG51 for photons? 1% higher, 3% higher, same, 1% lower, 3% lower. Ratio of TG51/TG21 ≈ 1% ← {0.9% 6mV, 1.0% 18mV, 1.3% 25mV

the uncertainties of the ratio ≈ 1.5%

0.5% due to data, procedures. the rest is due to the change in the primary standard used for chamber calibration.

A brachytherapy line source, with thee separate sources. What is the differnce in the dose rate for a point perpendicular to the center source relative to a point perpendicular to the end source.

What is the difference in a baormeter reading if the readings are taken aa a height of X and X+50 m.

What does the term sliding window mwan in IMRT

Couch kick on a cranial spinal treatment.

A sim-film is taken for a 100 SSD setup. Patient is treated at 80 SSD. What is the assumed Souce-to-Film distance to correctly cut the blocks for the new 80 SSD.

For a x ray tube with 100 mA and 100 kVp, the HU has a sigma of 1.5, if the current is raised to 400 mA, what is the new sigma of HU?

$P = P_b \cdot \exp[\frac{-g_0 M \cdot (h-h_b)}{R^* \cdot T_b}] = P_b e^{-\frac{0.029 \times 9.8 \times (h-h_b)}{8.3143 \times 273.15}}$

$= P_b e^{-0.000125(h-h_b)}$ ↓ at 0°

$= P_b e^{-\frac{0.0342}{T} \cdot \Delta h}$ ↓ If T in (273.2+C°)

P_b – Static pressure

T_b – standard Temp

h – height above see level

R – 8.31432 N.m/mol.K

g_0 – gravity 9.8 m/s²

M – molar mass of earth's air 0.0289kg/mol

$mag = \frac{SFD}{100}$

$mag = \frac{SFD'}{80} \Rightarrow SFD' = \frac{80}{100} \cdot SFD$

$\delta = \frac{1}{\sqrt{N}} \Rightarrow \delta = 1.5 \times 1/\sqrt{100/100}$

$= 1.5/2$

$= 0.75$

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 59Co 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 Do, n, what is Dq
- 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, Nx, Pion, Prepl, 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 treatnent 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.

r 'ar momentum, for particle:

$L = r \times p$ (p: linear momentum)

$= mvr \cdot \sin\theta$

for circular: $L = mvr$

angular momentum for subject:

$L = I\omega$

ABR Written Exam 2002

General Physics:

moment of inertia (rotational inertia)

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

A question about the angular momentum. $I = mr^2$ ($= \frac{2}{5}mr^2$ ball) $K = I\omega^2$ (ω: rad/s; I: kg·m²)

A weight is stiing on a beam that is supported by two cloumns. Given the location of the weight on the beam, calculate the force on each beam.

A electron travels from the cathode to anode (Voltage and distance was given). How long it take for the electron to travel this distance. $eV = \frac{1}{2}mv^2 = \frac{1}{2}mc^2 \cdot \frac{1}{1-(\frac{v}{c})^2}$ ⇒ V=?

$V_{av} = \frac{1}{2}V$ $t = \frac{d}{V_{avg}}$

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. $= 0.4e^{-\frac{\ln 2}{T_1}\cdot t} + 0.6e^{-\frac{\ln 2}{T_2}}$

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

Two isotope 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 (desities were given)

refrected

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

$\Omega = \frac{1.22\lambda}{d}$ $\left[L = \frac{d^2}{4\lambda}\right]$

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. 40 dB

RC circuits.

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

Beta plus decay, amu's are given. Calculate the max energy of the positron.

The hex equivalent to a binominal number.

Calculation of accumulated dose $1.44\,A^\circ\,T_{1/2}$

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

$A = A_0 \cdot e^{-\lambda t}$ ↳ $T_{1/2} = 60.2$ days

$\tilde{A} = \int_0^\infty A(t)\,dt$

$= 1.44\,T_e\,A_0$

$f\uparrow$ ⇒ focal depth ↑

$Q\uparrow$ narrow band width ⇒ doppler

$Q\downarrow$ broad ⇒ better axial resolution

$f\uparrow$ ⇒ better axial resolution

⇒ ↓ imaging depth ($L\uparrow$)

⇒ less divergency ($\Omega\downarrow$)

$f\uparrow\ \lambda\downarrow$

$L\uparrow$

if tell you uptake half life T_u ⇒

if uptake is not rapid in compared with T_P ⇐

$\tilde{A}_u = 1.44\,A_0\,T_e\,(T_{uq}/T_u)$ ↳ biologic uptake

$\frac{T_B T_P}{T_B + T_P}$ effective uptake half life

$T_{ue} = \frac{T_u T_P}{T_u + T_P}$

Calculate dose at cord given dose at prescription depth
Calculate total dose given several beams which traverse sevl 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 recieves most dose (axilla, cervical nodes...)
Combined photon/electron for parotid (why combine, typical ratio, ...)
Wedge transmission factor (Δ with depth, Δ with field size, dynamic wedge issues...)
Compensators (list included: independent of depth, 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 OAF
Table requirements for stereotactic radiosurgery
Purpose of dual fields for 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 rads during weeks 8-15...)
Primary barrier calc
Neutron detectors
Matching: use & occupancy factors
HDR emergency procedures
Package 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 electrometer/ion chamber system is used
TG-25: know specs for flatness, symmetry, uniformity index

BIOLOGICAL AND CLINICAL CONCEPTS

$TD_{5/5}$ (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 (list included: breast, Hodgkins, seminoma, prostate)
Matching: match $TD_{5/5}$ values with correct organ (list included: fetus, lung, optic chiasm...)
Know what PTV includes/represents
Meaning of α:β ratio
D_0 on survival curve represents...
Matching: match parts (alveoli, choroid,...) with anatomy (lung, eye,...)

ABMP part II (July 2000)
Chicago

- Similar questions to those listed in this book for ABMP 1999, part II. Also:
- Define brachytherapy functions, g, F, Λ
- Prescribed doses in TBI w/ photon and electron
- Prescribed doses in SPS, SRT, breast, prostate, seminoma
- 3-field treatment, 180cGy, gantry120deg apart, equally weighted, lateral beams pass through 6cm lung, what dose actually absorbed?
- 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?
- Brachytherapy definitions: anisotropy /geometry / radial functions
- Use of re-entrant ion chamber in brachytherapy source calibration
- Earlier NIST shortcoming in anisotropy function calculation of I-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!

	Per hr	per year
off	0.002rem Avg 0.01 rem max	
on	restrict	<1.25rem/quarter 5rem/year
outside	unrestricted 0.002rem/hr 0.1rem/wk	0.1rem/y

in water

photon energy (MeV)	τ	Δ	Π
0.01	95	5	0
0.026	50	50	0
0.150	0	100	0
24	0	50	50

typical DR for

point A	point B	bladder	surface

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 tissue?
Compton interactions - energy of backscattered photon
Know energy where photoelectric and compton interactions are ~ equally likely
Properties of Co-60 decay

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: α, N_x, A_{wall}, N_{gas})
Put the parts in tx head in order (list included: monitor chamber, target, collimators...)
Matching: match linac parts with appropriate functions (list included: magnetron, circulator, waveguide...)
Given MHz, calculate the size of each microwave cavity
kV issues(heat vs. brem efficiency, heel effect, output proportional to...)
MV transmission target properties
Methods to measure dynamic wedge
Methods of instant verification for in vivo dosimetry
Properties of LiF TLD
Properties of diodes
Problems with using film for measuring PDD

EXTERNAL RADIATION BEAMS

Matching: match electron energy with "rule of thumb" values (know R_p, %brem, R_{50}...)
Factors that affect virtual/effective SSD
Ideal properties of a phantom for an electron beam
If chamber in water phantom goes 5mm deeper on one side of CAX change in msmts =?
Properties of photon isodose lines
Most sensitive energy test
When electron beam is collimated to small field, what happens to output
Dose distribution for abuting electron and photon fields
What factors inc geometric penumbra
Issues when increase cone to skin distance for electrons

BRACHYTHERAPY

Calc air kerma strength from mgRaEq for Ir-192
Know typical DR for fletcher at: point A, point B, bladder, surface
Matching: match isotopes with appropriate factors (know HVLs, half-lives, average/max energies...)
Given DR at 1 cm perpendicular to Cs-137, what is the DR at 0.5 cm
Calculate DR at 1.5 m given mg of implant, Γ, 25% atten by pt, and a TVL shield
Know what point A represents
Factors affecting Sievert integral
Prostate implant issues (TRUS, typical doses, urethral complications wrt EBRT...)
Given total dose from permanent implant, calc dose delivered at point in time
Matching: match the essential info (ISL, exposure rate constant, 8.25 Rcm²/mgh...) with the source strength specification (mgRaEq, Air Kerma strength, apparent activity...)

RADIATION TREATMENT DESIGN

Esophageal tx planning (typical beam arrangement, does it depend on which 1/3, ...)
Lung tx planning – issues related to 6MV vs 18MV for small midlung lesion (e.g. build-up and build-down effects)
Calc dose from PAB given information for SCLAV

$f = F(m-1) = F\left(\frac{SID}{SOD}-1\right)$ — focal spot

penumbra

1 cal ⇒ 1 g water 1°C

1 cal = 4.19 J

Specific heat ⇒ # of cal to ↑ T by 1°C

Ice 1/2

Steel 1/8

ABR 2000 - Part 1 - Physics

J/m²

1. Calculate the kerma deposited by a beam with a photon flux of X and the following values for μ/ρ μ_{tr}/ρ.
2. Which of the following do not influence the MTF of film? (focal spot, SID, SOD, motion, recon)
3. The threshold of hearing is X W/m². A sound of Y W/m² corresponds to how many dB? $10 \log \frac{Y}{X}$
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 = 0.66? 2 + 0.26 = 2.26?
7. A 16 bit computer can access how many locations? 2^{16}
8. One hexadecimal digit can be used to count up to what number? 15
9. Which of the following would have the highest LET? α 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. (CO2)
12. If 0.1 kg of water is cooled from 40C to −80C, how much energy is lost? Given specific heat of water, specific heat of ice, and an additional constant (thermal fusion constant?). $E_{W\,40\sim0}$ E_{W-I} $E_{I\,0\sim-80^\circ}$
13. According to the uncertainty principle which of the following cannot be measured simultaneously. position & momentum.
14. The area of a copper plate is 0.1 m². The coefficient of linear expansion is provided. If the temperature increases from 22C to 100C, what is the new area? $\Delta A/A = 2\alpha\Delta T$ $\Delta A/A = 2\alpha\Delta T$
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?

$\frac{dX}{dt} = \Gamma \cdot \frac{A}{r^2}$ $D = \frac{1}{\rho} \cdot \frac{dX}{dt} \cdot T$ 1 mSv/y → 1 Sv/week.

$\frac{50\,mSv}{52\,week} = (60mg \times 8.25\,R^*cm^2/mg\cdot hr) \times \frac{1}{50^2} \times T(hr)$

T = 4856 hr

NO ln2 here!

$0.53 = e^{-2/D_0}$

$\Rightarrow D_0 = 3.154\,Gy$

$\log_e n = \frac{D_q}{D_0} \Rightarrow n = e^{0.8/3.15} = 1.17$

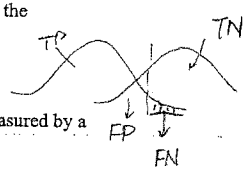
$\frac{N}{N_0} = [1-(1-e^{-D/D_0})^n] = 1-(1-e^{-30/3.15})^{1.17} = 0.000085$

$R_g = 10000/10 = 1000\,cpm$ $R_b = \frac{19200}{30} = 640\,rpm$

$R_s = 1000 - 640 = 360\,cpm$ $\Delta = \sqrt{\frac{R_a}{t} + \frac{R_b}{t}}$

MDA = $3\sqrt{R_b/t}$ = 33

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? $= \sqrt{\frac{10000}{10} + \frac{360}{30}} = 148 \pm 15$ 360 ± 15 cpm
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? $b(x,n,p) = \binom{n}{x} p^x (1-p)^{n-x}$
20. Question on the f-stop of a camera. $f\# = 2$ $f = 15\,cm$ $diameter = \frac{f}{f\#}$
21. Given attenuation coefficient. What percentage of the incident photons is absorbed between a depth of 1 and 2 cm? $= I_0 | I_1 | I_2$ $I_2 = I_1 \exp(-u)$ $I_1 = I_0 \exp(-u)$ $I_2 = I_0 \exp(-2u)$ $\Delta I = \frac{I_1 - I_2}{I_0} = \frac{I_0\exp(-u) - I_0}{I_0} = \exp(-u) - \exp(-2u)$
22. What is the increase in the total equivalent dose for an AP versus a PA radiograph? The dose to each organ (breast, thyroid, lung, and heart) is provided along with w_T for each.
23. A nonparalyzable records 450 cpm. It has a deadtime of x. What is the true count rate? $R_t = R_0/(1 - R_0 t) = R_g = R_t e^{-R_t t}$
24. D_q = 0.5 Gy. 2Gy is required to reduce the surviving fraction to 0.53. What is the surviving fraction if 30Gy 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? 0.8% → 8 %/Sv
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. $S = \frac{TP}{TP+NF}$

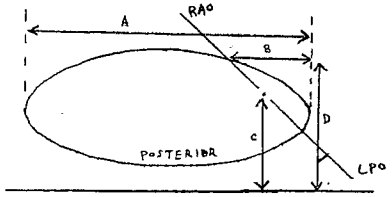


27. Effective half-life problem.
28. Doppler effect. Given velocity of train, calculate frequency of a sound measured by a stationary observer. $f'' = \frac{v - v_s}{v} \cdot f$
29. 1e15 bytes is a petrabyte, terabyte, gigabyte…
30. question involving rms voltage

$V_{rms} = \frac{\sqrt{2}}{2} V_{peak}$ for sin wave form

(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.



(4) 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.

(5) 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 d_{max} 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.)

(6) 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.

(7) Some legitimate, clinically relevant questions on make-up doses for mistreated 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.)

HDR calibration

(R/h) @ 1m in air

$S_K = 8.76\times10^{-3} \dot{X}$ (m^2 uGy/hr) (8)

$S_K = I \cdot P_{TP} \cdot P_{elc} \cdot N_C \cdot A_{ion} \cdot P_{ion}$ (9)

I: current reading; T·P: temperature-pressure; P_{elc}: electron meter correction factor; N_C: chamber calibration factor; HDR calibration

A_{ion}: chamber ion recombination correction at the time of chamber calib (10)

P_{ion}: recombination correction at source calibration

$\dot{D} = S_K \cdot \Lambda \cdot \frac{G(r,\theta)}{G(r_0,\theta_0)} g(r) \cdot F(r,\theta)$

Assume both SSD setup

dme, dmp can be found on PDD table

$\begin{cases} D_{3cm\text{-}p} = D_{dmp} \cdot PDD_p(d=3) \\ D_{3cm\text{-}e} = D_{dme}\ PDD_e(d=3) \end{cases}$

$D_{3cm\text{-}p} + D_{3cm\text{-}e} = 55$

$\begin{cases} D_{s\text{-}p} = D_{dmp} \cdot PDD_p(d=0) \\ D_{s\text{-}e} = D_{dm} \cdot PDD_e(d=0) \end{cases}$

$D_{sp} + D_{s\text{-}e} = 40$

$D_{med} = M \cdot N_{gas} \cdot \left(\frac{\bar{L}}{\rho}\right)^{med}_{air} \cdot P_{ion} \cdot P_{rep} \cdot P_{wall}$

Had to determine if a linac 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-21?

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.

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 polyethelyene, etc. ⟹ lead & BPE

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/Ci hr instead of 3.26 R cm²/mCi hr. All answers were ≥ 1 HVL.

0.0005 mGy/hr
0.05 mR/hr
↑ 40 hr/wk
0.002 mSv/wk
and 2 mR/hr only

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.

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

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

$\left(\frac{1}{2}\right)^{HVL} = 0.511$

$HVL = 1$

$e^{-(\mu \cdot TVL)} = 0.1$

$-\mu \cdot TVL = \ln(0.1)$

$\mu = \frac{-\ln(0.1)}{TVL}$

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

$n = (-\log B)$

$\left(\frac{1}{2}\right)^{n'} = B$

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

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 point each)**

(1) Given a picture of non-wedged profile scans obtained using a scanning water tank, questioned asked what was wrong with the superficial-most profile (which appeared somewhat wavy in comparison to the others). worse 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 ($d=10cm$)

(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, hand-held ion chamber) as well as different sizes of ion chambers (e.g., 1 cc, 10 cc, or 100 cc). • the angle between isodose curve and the normal to the central axis

Simulator → KV range X-rays ⇒ ion chamber 100cc

(5) How much dose is delivered from I-125 after 45 days given its half-life and initial dose rate? $D = \dot{D}_0 \cdot T_{avg}\left(1 - e^{-\frac{\ln 2}{T_{1/2}} \cdot 45}\right) = \dot{D}_0 (59.4 \times 1.44) \times \left(1 - e^{-\frac{\ln 2}{59.4} \times 45}\right)$ • the angle ↓ with ↑ of depth because of scattering

(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? ~~$35~~ - 2067 (semi-annual) Quarterly LDR/HDR afterload quarterly check 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. $\Omega = 2\pi(1-\cos\theta)$ noisy autoradiograph

(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 other should be same?

(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.

rem counter → BF_3 proportional counter surrounded by 9inch cadmium-loaded polyethylene sphere

1600 ~ 2000V

thermal neutron ~ 10meV neutron

(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.)

(12) One question about the uses and limitations of LiF TLD detectors for use in a radiation therapy department. Specifically, their accuracy, linearity, etc. linear → 10Gy low energy dependence 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 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) 2Gy

(15) What's the dose to a kidney that will cause irreparable damage? 20Gy { 2300 cGy → TD 5/5 ; 2800 cGy → TD 50/5

(16) One question on use of bubble-type neutron detectors. passive type both inside/outside room, but not 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. $d_{eff} = d - z(1 - CET)$

(19) About 5 or 6 questions on TG-51.

(20) One TG-56 question about coefficient of variation of measured seed strength before you should notify the company of any discrepancies. ⇒ 3% investigate 5% report to manufacture

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 at least % or 2 ribbons **(3 points each)**

(1) Several inhomogeneity calculations for electrons and photons 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.

physical size < 4mm²

$W_{TBL} = D_{TBL} \cdot d^2$

For primary leakage scatter

TBI workload
Ex: Non TBT $W = 300$ cGy/wk $U = 0.21$
TBI dose = 12Gy/wk $d = 4m$
$W_{primary} = \frac{U \cdot 300}{\times 0.21} + 12 \times 4^2 = 300 + 192 = 255$ Gy/wk
$W_{scatter\ from\ TBI\ patient, TBI\ Barrier} = 255$ Gy/wk
$W_{scatter\ from\ 360\ cc}$ 300 Gy/wk
$W_{average} = 300 + 192 = 492$ Gy/wk.

2004 Part 1Writtens

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 ~1.7Mbits/sec, how many minutes for the transfer? (You'd have to know the standard bit depth of a CT image). 4-1 m → 5.88 min

2. A terabyte is equivalent to:
a. 10E4
b. 10E5
c. 10E6 10^{12}
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

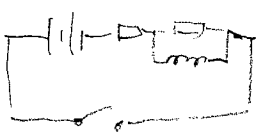
5. If a sample has 1600 total counts in 4 minutes and the background has 900 total counts in 3 minutes, the activity of the sample is 100 +/- 14 cpm.

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? N=50 N=2500

There was one circuit:

7. 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 → ∞? 0

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? $Y = 2t - e^t$ ln 2

There were a few questions on ultrasound, such as: crystal

9. Ultrasound transducers transmit and receive pulses using what effect? piezoelectric

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

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? 30

17. If a patient is 8 HVLs thick, what's the ratio of entrance exposure to exposure at midpoint? 10

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? $\frac{4 \cdot e^{-\mu_L 20}}{e^{-\mu_H 20}}$

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

$\frac{\ln 10}{TVL} = \frac{\ln 2}{HVL} = \frac{\ln 5}{FVL} \ldots$

$\left(\frac{100}{523}\right) = \left(\frac{f+10}{f}\right)^2 \Rightarrow 26\,cm$.

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 ↪

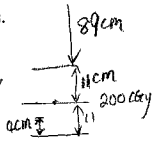
55. Purpose of the guard ring in a plane parallel chamber is to? A. "Define the collection volume" appeared to me to be the only reasonable answer.

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

57. Dose to cord from AP/PA 100 SAD setup. 22cm separation, cord 4cm deep, 200cGy to isocenter. TMRs given.
$D_{mp} = DR \cdot mu \cdot TMR(d=11)$
$D_{cord} = DR \cdot mu \cdot \left(\frac{100}{104+4}\right)^2 \cdot TMR(d=4)$
$D_{cord} = DR\,mu \left(\frac{100}{100+7}\right)^2 \cdot TMR(d=18)$

58. Most radiation sensitive part of the eye is ….. lens

59. TVL is related to HVL by A: TVL = ln10/ln2 HVL, B… other impressive but erroneous relationships.
This rule and it's generalization can be used to speed up all sorts of calcs, not just in shielding but with regard to time as well – use it!



$\left(\frac{1}{10}\right)^{\frac{X}{TVL}} = \left(\frac{1}{2}\right)^{\frac{X}{HVL}}$

$\frac{X}{TVL}\ln\left(\frac{1}{10}\right) = \frac{X}{HVL}\ln\left(\frac{1}{2}\right)$

$\frac{TVL}{HVL} = \frac{\ln\left(\frac{1}{10}\right)}{\ln\left(\frac{1}{2}\right)}$

$TVL = \frac{-\ln 10}{-\ln 2} \cdot HVL = \frac{\ln 10}{\ln 2} HVL = \frac{2.303}{0.693} HVL = 3.32\,HVL$

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.
$OD = \log\frac{I_0}{I_t} = \log 200 = 2.3$

61. Electrons at extended SSD, which is true?
A. Width of the 90% extends proportionately (B.) Penumbra increases C. Output follows 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) (15cm, 20cm) > lateral scatter equilibrium ⇒ field equivalence ⇒ the same PDD along CAX but different output factors.
⇓
no change in surface dose (%)
⇓
relativity !!
If assume FS 15→20cm and no mu change
- output ↑ D_{dm} ↑
- % skin dose →
- abs skin dose ↑

63. Why does the equivalent square technique work? (A.) Because scatter doses are equal between square and rectangular fields, 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_L + 1HVL, B other options including Ts + T_L, Ts + 1TVL. (T_L or Ts which is greater) + 1HVL

65. Order of materials in door for high energy linac – inside to outside.
lead + BPE + lead

66. Electron backscatter from internal shield versus Energy and Z – just had to know increase vs decrease.
E backscatter ↗ with Z↑ ↘ with E↑

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. ⇒ leakage 0.1%, redundancy D, collecting potential D.

69. Classic isocentric POP 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/mu 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 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.
D = (DR.T) · BSF · PDD · $\left(\frac{SSD}{FSdm}\right)^2$

71. Had to do single field 125 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. ↳ in water?
$D = DR \cdot MU \cdot Sp \cdot Sc \left(\frac{100}{125+dm}\right)^2$

72. Multiple beam plan. AP weighted to 100% at dmax, laterals weighted to 100% at dmax. 200 cGy delivered to 238% isodose line. Dose delivered by AP beam is ??? cGy.
200 / 238% = 84.0cGy → 100% dose → AP beam. · PDD (F)

73. Monte Carlo calculations require a random number generator and … (A.) probability distributions, B,C,D,E other options that didn't look right.

74. Dose 10cm deep 5cm outside field is (A.) 1% B. (2%) C. 3% D. 4% E. 5% (high E → under block 20%; ^{60}Co → For Co) Exp 7. in Kahn & book

75. Γ factors given on several questions were not what I expected for the isotope in question. But I always used the one given.

76. Pacemaker dose limit. ⇒ TG34 2Gy if total dose > 2Gy · pacer maker function should be checked 2Gy-10Gy

77. Apparent mCi is (less) / more / same as mCi → encapsulation effect

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%
e beam flatness constancy : 3%
X ray + e^- : Symmetric 3%

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. $S/\rho \cdot \rho = S \Rightarrow$ MeV/cm $\left(\frac{18\text{MeV}}{S}\right) = \text{cm}$

28. HDR 192Ir. Patient treated with time XXX with Activity YYY on Aug 15th. Source replaced with activity ZZZ on Aug 17th. Treatment time on Aug 22nd is ? No 192Ir half life given. 1% decay per day tx on Aug 17th $= (YYY/ZZZ)\cdot XXX$. tx on Aug 22nd $= (YYY/ZZZ)\cdot XXX \cdot e^{\frac{5}{T_{1/2}}\ln 2} = \left(\frac{YYY}{ZZZ}\right) XXX \cdot 1.048$

29. Nothing on TBElectron

30. 10MV through 6cm lung, dose actual vs dose without inhomogeneity. No other data given. Increase of dose beyond lung: 10MV 4%/cm 4MV 3%/cm 6MV: 10MV: 2%/cm 25MV 1%/cm

31. A question involving 10mg Ra – simple application of ΓxA/d2 – but needed to know (ie not given) exposure rate const. = 8.25 Rcm2/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% ⇒ 3 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. $120 \times \frac{140}{102} = 165\text{cm}$. magnification: (140/102) 10x10 field ⇒ 13.7@ film

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 at 13.7cm @ SFD ⇒ SFD = 165cm

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

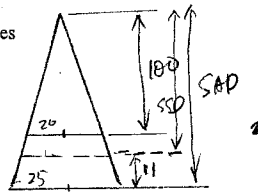
40. I'm vague on this one but I'll give it to you anyway. The question went like …. The simulator couch wouldn't go low enough, so the film was taken at X SSD, separation 25 cm, distance to film = 140 cm. Physician wants to treat at 132 SSD, simulator film needs to be placed at what distance to cut blocks.

Assume SAD TX

$\text{mag} = \frac{140}{X+12.5} \Rightarrow \text{SFD} = \frac{140}{X+12.5} \times (132+12.5)$

$\text{mag}' = \frac{\text{SFD}}{132+12.5}$

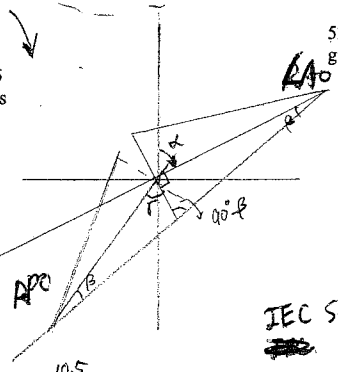
or SSD tx: $\text{mag} = \frac{140}{X} \Rightarrow \text{SFD} = \left(\frac{140}{X} \cdot 132\right)$



$\text{SAD} = 100 \times \frac{25}{20} = 125$

$\text{SSD} = \text{SAD} - 11 = 125 - 11$

$= 114$



$\gamma + \beta = 90 - \beta$

$\gamma = 90 - 2\beta$

$G_2 = \alpha + 90^\circ + \gamma$

$= \alpha + 90 + 90 - 2\beta$

$= 180 + \alpha - 2\beta$

$\beta = \arctan\left(\frac{F}{2\times 100}\right) = \arctan\left(\frac{10.5}{200}\right)$?

IEC Scale

$\Rightarrow G_2 = 218.9^\circ \Rightarrow 360^\circ - G_2$

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

(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 ⇒ high Energy

43. Beam steering vs gantry angle in a linac. Signals to steer originate from ….. ion chamber …. various other options. transmission ion chamber ⇒ { monitor dose rate & integral dose; angular and radial distribution of radiation beam

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. ↓ normalized relative measurement

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) Bremstrahlung B. Output Factor, C. Depth of 80%, D. Surface Dose. (Rp) ↑ Bremstrahlung interaction; { scattering foil, chamber, collimator jaws

47. I50 ionization depth of an electron beam is 5.1 cm. The energy of the beam is ….. ↓ ↓ ↳ if FS < lateral scatter equilibrium. PDD change, dmax shift toward surface

48. Saturation in an ionization chamber refers to …. (A.) voltage high enough to prevent recombination ….other options that were not correct. → $R_{50} = E/2.33$

$R_{50} = 1.029\, I_{50} - 0.06$ 0.0

$= 4.647\, 6.188$

$E = 4.647 \times 2.33$

$= 10.8$ MeV

12.08

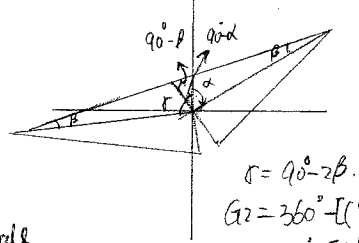
49. A survey points a linac beam at a primary wall and measures 2mR/hr. Is this OK? There were various options in the answers, but this was the point of the question.

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.

0cm		Block 6cm		9cm	10cm

52. Classic electron ISL calculation straight from Kahn, ie calculate the effective SSD, given energy, field size, dmax (2cm), given slope of $(\text{Io/Ig})^{1/2} = 0.0111$. → effective SSD



dose with zero gap ← $\frac{Io}{Ig} = \left(\frac{ftd+tg}{ftd}\right)^2$

↓ dose with gap g between standard SSD and surface.

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

$G_2 = 360^\circ - [(90^\circ - \alpha) + \delta]$

$= 360^\circ - [90^\circ - \alpha + 90^\circ - 2\beta]$

$= 180^\circ + \alpha + 2\beta$

1. A B C
1 2 3

$D_A = D_{1A} + D_{2A} + D_{3A}$

$= DR \cdot T_1 + DR \cdot T_2 \left(\frac{1}{\sqrt{2}}\right)^2 + DR \cdot \left(\frac{1}{\sqrt{5}}\right)^2 \cdot T_3$

$= 1.2 \cdot DR \cdot T_1 + \frac{1}{2} DR\, T_2$

$D_A = D_B$

$\Rightarrow 1.2\, DR \cdot T_1 + 0.5\, DR \cdot T_2 = DR \cdot T_1 + DR\, T_2$

$\Rightarrow 0.2\, T_1 = 0.5\, T_2$

$\Rightarrow T_1 = 2.5\, T_2$

$D_B = D_{1B} + D_{2B} + D_{3B} = DR \cdot T_1 \left(\frac{1}{\sqrt{2}}\right)^2 + DR \cdot T_2 + DR \cdot T_1 \left(\frac{1}{\sqrt{2}}\right)^2$

$= DR \cdot T_1 + DR\, T_2$

2004 ABR Therapy Part 2, Written.

1. HDR, three dwell positions (1, 2 and 3 – 2 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 A equal dose B.

$P_{pol} = \left| \frac{M^{+}_{raw} - M^{-}_{raw}}{2 M_{raw}} \right|$

2. TG51 question (no TG21 in whole exam). Given Ppol, Pelec, T (deg C), P (mmHg), Vhigh = +300V, Vlow = +150V, 100mu Reading for Vh = 1.71 …., 100mu reading for Vl = 1.70…., given 60CoNdw Gy/C for chamber, given pdd photon, given kQ (not asked to do energy determination to find kQ) calc cGy/mu at dmax for photon beam. Answers approx 0.6% apart. (Also given plenty of irrelevant information such as TG51 electron beam parameters)

$P_{ion} = \frac{1 - V_H/V_L}{M^{+}/M^{-} - V_H/V_L}$

$P_{TP} = \frac{273.2 + T}{295.2} \times \frac{760}{P}$

$M = P_{ion} \cdot P_{pol} \cdot P_{elec} \cdot P_{TP} \cdot M_H$

$D^{Q}_{w} = M \cdot k_Q \cdot N^{60Co}_{Dw}$ @ 10cm. $D^{Q}_{w@dm} = D^{Q}_{w} / PDD(d=10)$ or TMR

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 profession not 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.

$K_{wk} = \frac{P \cdot d^2}{W U T}$ [8x0.3054 L]^2

$= \frac{(0.002\, R/wk) \cdot [12ft - 48'' + 1m]^2}{(800\, mA.min/wk) \times \frac{1}{4} \times 1}$

$= 1.18 \times 10^{-4}\ R/mA.min$

4. AP/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? Cord dose = 62 + 150 x 0.18 = 89 cGy → should provide more info: 60Gy/30fx to tumor

$fx = 4000/89 = 45$

$\begin{cases} 89 \cdot x + 212\, y = 4000 \\ x + y = 30 fx \end{cases} \Rightarrow \begin{cases} x = 19 \\ y = 11 \end{cases}$ (4.69)

efficiency $\in$ (5)

$\frac{x\,(cpm)}{y\,(mCi)}$

5. Counts given (cpm) for reference source with known activity (mCi). How many counts allowed to stay below wipe test leakage limit – limit not given (5nCi?).

(5nCi)

$5(nCi) \times \frac{X(cpm)}{Y(mCi)} = \ldots$

6. 2cm diameter lead pig inside polyurethane foam inside 30cm diameter shipping drum. HVL Pb given. Exposure rate constant of 192 Ir given (but not the one I know!). Calc max activity to keep below 50mR/hr on surface. Another variant of this question used 137Cs (again I didn't recognize the exposure rate constant provided), activity provided and asked to calc thickness of lead to reduce exposure rate to certain level (TVL given).

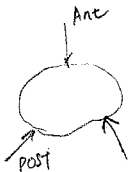
$A\,(mCi) \cdot \Gamma\,(R \cdot cm^2/hr \cdot mCi) \cdot \left(\frac{1}{2}\right)^{2/HVL} \cdot \left(\frac{1}{30cm}\right)^2 = 0.05\, R/hr$

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

8. TBI, diode reading 450cGy on surface, presc midline 600cGy POP laterals, 30cm separation. TMR's given, 350cmSSD. 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 Fluorescent screen → liquid ion chamber / solid state detectors (silicon diodes) / Zinc tungstate scintillating / Amorphous silicon (a-Si)
mirror → replace by fiberoptics system
CCD/video camera

Light/Rad field coincidence 2mm or 1% on a side, whichever is greater.



$d = 15cm$.

$d_{eff} = 15 - 9 + 9 \times 0.33 = 8.97cm$

$MU_{post} = \frac{Dtd}{DR \cdot TMR(d=8.97)}$

$\frac{MU_{ant}}{MU_{post}} = \frac{TM(d=9)}{TMR(d=15)} > 1$

$MU_{ant} = \frac{Dtd}{DR \cdot TMR(d=15)}$ $= \frac{0.8}{0.659}$

9. Three beams 120 deg apart, AP and post obliques. 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.

$(\frac{1}{3} D_{mp}) / D_{dm} = PDD$

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. (per cGy)? mSv/Gy

14. Neutron dose equivalent ratio 18MV vs 15 MV. Answers were fairly widely separated ie 1, 2, 5, 10, 100. 1~2

15. Given distance iso to maze (d_1) and maze length (d_2), neutron dose at iso (mSv) per photon cGy at iso 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. $H = H_o (mSv/Gy) \cdot \frac{\varepsilon_o}{S_1} \cdot \left(\frac{d_o}{d_1}\right)^2 \cdot \left(\frac{1}{10}\right)^{d_2/5}$

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

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

dual scatter only for high E electro

18. g(r) for 125I vs 103Pd. A. same at all depths, B. Pd exceeds I beyond 1cm, C Pd exceeds I beyond 4cm, D. I 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. ⇒ 3%

22. TG 40 photon flatness spec. Electron X-ray beam flatness constancy ⇒ 2%

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.….

25. TBI – what is not true A. Dose Uniformity < 15% B. Tissue Equivalent compensators are used C. High SSD D. AP preferred over lateral.

Dose uniformity ~ 10%
High E preferred.

well ionchamber
leakage
Redundant check } E. { 2% D
all other test ⇒ I.
Linearity ⇒ I. 2 years

0.1% → For both local standard and field instruments leakage, collecting potential should be checked Each use.
Table IV.