(26). IMRT constraints for head & Neck
brainstem ≤5400 cGy; 1cc ≤6000
optical chiasm/optical nerves: ≤5400 cGy, 1cc≤6000cGy
temporal lobes: ≤6000 cGy, 1% ≤6500
Cord: ≤4500 cGy, 1cc ≤5000 cGy
Cochlea: ≤6000 cGy
Eyes: <3500 cGy
lens: abap

parotid: mean dose ≤2600 cGy in at least one gland, or 20cc of both glands ≤2000 cGy
glottic larynx: mean dose ≤4500

2006 ABR Part II – Therapy Physics Type

1. For what isotope is the ratio of dose at d=5 cm to the dose at d=1 cm the lowest? Co, Cs, I, Pd? Pd. (low E)

2. How often are ~~electron energies~~ checked according to TG-40? Once a week, Once a week if they are used, twice a week, etc.?

3. DVH - which plan has the lowest fraction of volume receiving 15-20 Gy?

4. What measurement device is best for a simulation room survey? ion chamber, ion chamber w/ electrometer, GM, scintillation counter? → for voids & defects. need quantitative measurement.

5. If a patient is prescribed 200 cGy a fraction with 30% open and 20% wedged for each field, what dose does the patient receive if the wedge is put in the wrong field? WTF=0.25. ⇒ 60%, 40%
$D_W = 200\times0.4 = 80$ cGy ⇒ $MU = \frac{80}{0.25\cdot CF} = 320/CF$
$D_O = 200\times0.6 = 120$ cGy ⇒ $MU = \frac{120}{CF}$
$D_W' = \frac{320}{CF}\cdot CF = 320$, $D_O' = \frac{120}{CF}\cdot CF\cdot 0.25 = 30$ } $D_t = 350$

6. What is the definition of wedge angle?

7. Given lots of TG-51 parameters, calculate cGy/MU for photons. $D^{Co}_{w} = D_{w}\cdot k_Q (M_{raw}\cdot P_{ion}\cdot P_{elec}\cdot P_{pol}\cdot P_{TP})$

8. Given lots of TG-51 parameters, calculate cGy/MU for electrons. $D = (P_{gr} k_{R50} k_{ecal}\cdot M)\cdot D^{Co}_{w}$

9. With 6 MV incident on x1 mm tissue then x2 mm bone then x3 mm lung, what is the dose to the proximal (or distal, I forget) part of the lung? proximal: −0.2cm × 2% = −0.4%; distal:
1mm, 2mm, 3mm

10. Shown CT with depths of tissue and lung, single direct field, and attenuation coefficients, what is the dose w/ and without heterogeneity corrections? $CF = \frac{TAR(d_{eff})}{TAR(d_1)}$
$CF_{Fe} = \frac{TAR(2+\theta)^{\rho_b}}{TAR(3+\theta)^{1}}\cdot\frac{TAR(\theta)^{\rho_L}}{TAR(\theta)^{\rho_b}}$
$CF_B = \frac{TAR(1+3)^{\rho_b}}{TAR(2+3)^{1}}\cdot\frac{TAR(3)^{\rho_L}}{TAR(3)^{\rho_b}}$

11. Given mixed energy, electron and photon, dose to surface = 40 Gy and PDDs at surface for each given, and dose to d=5 cm = 55 Gy, PDDs for each at d=5 given, what are the relative contributions of photons and electrons at dmax?

12. Mammosite balloon w/ diameter = 4 cm and Rx point at 1 cm from surface of balloon. What is the minimum balloon to skin distance to minimize the hot spot to 150%?
$D\cdot(\frac{1}{3})^2 = 100\%$
$D\cdot(\frac{1}{r})^2 = 150\%$
$\Rightarrow (\frac{r}{3})^2 = \frac{1}{1.5} \Rightarrow r = 2.45$ cm
distance = 2.45 − 2 = 0.45 cm

13. What thickness of Al to compensate for 5 cm of missing tissue? $T = (\frac{5cm\cdot 0.7}{\rho_{Al}})$

14. Dose at point S is 6 mrem/hr. How much concrete shielding to get dose at point Z less than 2 mrem/hr. Point S is 6 m from iso and Point Z is 12 m from iso. Given TVL of concrete.
$D(Z) = D(S)\cdot(6/12)^2 = 6\times 6^2/12^2 = 1.5$ mrem/hr

15. If the daily output is greater than what % is patient treatment suspended immediately according to TG-40? 5%

16. What is the overall uncertainty in dose delivered to a point in a patient with all uncertainties taken into consideration? Kahn - 5.6%

17. What method cannot be used to verify an IMRT plan? Film, point hand calc?

18. What is the purpose of the bending magnet?

(11)
$D_s = D_{mp}\cdot PDD(0)_p + D_{me}\cdot PDD(0)_e$
$D_{5cm} = D_{mp}\cdot PDD(5)_p + D_{me}\cdot PDD(5)_e$
⇒ $D_{mp} =$, $D_{me} =$ } can be at different depth!

19. Where are the electrons generated in a linac? electron gun

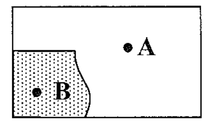
20. What does Gamma measure?

21. Calculate collimator angle for opposite lateral brain fields to match the divergence from a spine field. Field size 27cm, Spine inferior 20cm and spine superior 17cm. $\tan^{-1}(17/100) = 9.65°$
couch $= \tan^{-1}(27/2/100) = 7.69°$

22. Skyshine steradian question. $\Omega = 2\pi(1-\cos\theta) = 2\pi(1-\frac{1}{\sqrt{1+0.2^2}}) = 0.122$ (Ster)
$\theta = \arctan(0.2/1)$ ⇒ 40x40 field size; solid angle for a beam with a circular cross section

23. Shown GTV, CTV and PTV asked to identify the PTV

24. Given the dose at A, find the dose under the block at the same depth at B.



$D_B = D(open) - (1-TF)\,D(block)$

25. When to check the wedge interlock monthly

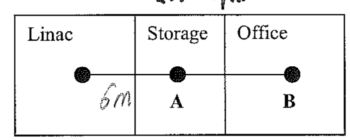
26. IMRT Head and Neck treatment. What are the dose constraints for critical organs.

27. The tolerance dose for the kidney TD5/5: 2300 cGy TD50/5: 2800 ⇒ 2000 cGy

28. Scanning PDD curves given and asked to identify which is which.

29. What is the reference depth used in photon beam calibrations (per TG-51) 10 cm

30. Shielding problem. Distances given: Linac to A=6m, Linac to B=12m. Survey meter measures xx mrem/hr at point A. Dose delivered at each treatment is also given. How many patients can be treated to limit the exposure at point B to below 2 mRem/wk or 2mR/hr



5mrem/hr

31. Gamma strength problem related to HDR treatment.

32. Question on changing Brachytherapy sources from ^{192}Ir to ^{125}I (or vice versa) and calculating activity/dose rate.
^{192}Ir: $(4.69\,Rcm^2/hr\cdot mi)\cdot(A_{app})\cdot f(0.965\,cGy/R)\cdot(\frac{1}{d})^2 = \dot{D}$
or $S_K(U)\cdot(1.11\,cGy/hr/U)\cdot G(r,\theta)_0\, g(r)\cdot F(r,\theta) = \dot{D}$

33. IMRT dose verification using small volume chamber (0.1cc). What should it's resolution (or measured error) be in order to be able to use for dose verification (ans: 0.1%, 0.5%, 1%, 3%, 10%)
^{125}I: $S_K(U)\cdot\Lambda(cGy/hr\cdot cm/U)\cdot G(r,\theta)\, g(r)\cdot F(r,\theta) = \dot{D}$
0.94 ~ 1.036

photon hot, electron cold.

34. Beam abutment question. Patient treated with 10MV photons and 16MeV electrons. Field size given. At 5cm depth what would be the case (photon side hot spot:electron side cold spot, photon side cold spot:electron side hot spot, both sides hot spots, both sides cold spots or no hot spots)

35. Morning (daily) QA for a HDR brachytherapy treatment source per TG-40 →

Table XIII QA for remote afterloading
door interlock; lights, alarms
console functions, switches, batteries.
visual inspection of source guide
verify accuracy of ribbon preparation

36. Daily output tolerance for X-ray and electrons (3%:5%, 3%:3%, 2%:3%, 5%:5% etc) 3%, 3% constancy

37. $E_p = E_0\,(1\text{-}d/R_p)$ given that at depth d1, the energy is E1 and at depth d2 the energy is E2, at depth d3 what is the energy

$E1 = E_0(1-d1/R_p)$, $E_2 = E_0(1-d_2/R_p)$ $\Rightarrow$ $E_0 = ?$, $R_p = ?$

38. Question on backscattering using block for electron beams. How does it change with energy E and Z. (increase when E and Z increases, decreases when E and Z decreases, Increases when E increases and decreases when Z increases and vice versa) ↗ with Z↑. ↓ with E↑.

39. This time there were about 4-5 questions about the TG-51. We were provided all the detailed information about the different factors and asked to calculate the Mu's/cGy to deliver at Dmax. 2 questions about the Photon beam and 2 question about the e -beam. In some questions you have to calculate the Pion & Ppol.

40. HDR shielding calculation. Everything was provided. Just use the formula and answer was there. ⇒ check

41. One beam profile diagram was provided with profile line variation at the surface. The reason for that.....Ans was---Water fluctuation.

42. Shielding calculation. the thickness was calculated as per the 6 MV beam and the Exposure level was given at particular point. question was to calculate the exposure level if 18 MV beam is used for the same thickness. TVLs were given.

$$D_{6mv} = D\cdot(0.1)^{\frac{thickness}{TVL_{6mv}}}$$

$$D_{18mv} = D\cdot(0.1)^{\frac{thickness}{TVL_{18mv}}} = \frac{D_{6mv}}{(0.1)^{\frac{thickness}{TVL_{6mv}}}}\cdot(0.1)^{\frac{thickness}{TVL_{18mv}}}$$

√ Khan's book:
occupation 50mSv/yr
public: 1mSv/yr or 5mSv/yr → more relevant for HDR.

Ir^{192} → 0.38MeV.
TVL: 5.8 inch concrete
$\Gamma_\delta = 4.69\,R\,cm^2/mCi\cdot hr$.
$f = 0.96\ cGy/R$

To calculate dose at maze dose

$$H = \frac{(10Ci)\cdot\Gamma_\delta\cdot\alpha\cdot Area}{d_1^2\cdot d_2^2}$$

α: reflection coeff $2\times10^{-2}/m^2$
Area: area of scattering at facing wall.
d_1: distance from source to wall
d_2: maze length.

From McGinley:

$B = \frac{P\cdot d^2}{WT}$ ← m or cm depends on W @ m or cm

(cGy/wk) @1m. → $W = \Gamma_\delta\cdot f\cdot A\cdot t$ ← McGinley use 4.8 R/

$= (4.69\,Rcm^2/mCi\cdot hr)\cdot(0.96\,cGy/R)\cdot(A\,mCi)\cdot(t\ hr/wk)$

$$t = \frac{(\text{Dose per patient})\cdot(\#\text{ of patients})}{(\text{dose rate @ 1cm})}$$

↳ 1Gy/min for 10Ci Source can be assumed.

For example:
10Gy per patient, 25 patients per week

$\Rightarrow t = \frac{10\times25}{1} = 250\,min.$

$W = 4.69\times0.96\times10{,}000\times\frac{250}{60} = 1.876\times10^5\ cGy/wk$ @ 1cm
$18.76\ cGy/wk$ @ 1m.

McGinley mention that dose rate in the maze falls off slower than IVS.

HDR

TG-56: Table V.

Daily QA: for remote afterloading facility:

- verify dose delivery accuracy
  dose, time, source strength
  time accuracy
- overall system function.
  simulated treatment
  treatment status indicator lights
  critical source control functions
- safety.
  door interlock.
  area radiation monitor
  A/V communication
  emergency equipment.
- positional accuracy 1mm
- temporal accuracy

TG-59:

(1) correct function of:
battery. A/V treatment status. A/V communication.
radiation monitors. simulated treatment.
door interlock. alarms.

(2) Accuracy of:
delayed source strength programmed in TPS and treatment unit
timer. radiation output using tertiary standard or timer spot check.
source position.

(3) Availability, condition, function of
emergency kit and tools.
instructions.
survey meters.

2007_Therapy_Part II_Type

Threshold energy for (γ,n)

	MeV
Al	13.1
Fe	13.4
Cu	9.9
W	6.19
Pb	6.74

photoneutron production $^{A}X(\gamma,n)^{A-1}X$

Energy spectrum: peak value: 2MeV of spectrum
evaporation neutrons (majority); direct neutrons (15%)

Φ (# of n per cm²) $= \Phi_{dir} + \Phi_{sc} + \Phi_{th} = a\frac{Q}{4\pi d^2} + 5.4a\frac{Q}{S} + 1.26a\frac{Q}{S}$

Q: neutrons per Gy (#/Gy)

Ho: neutron dose equiv. at distance do (1.4m) from target. (mSv/Gy) range 0.82~2.3 for 13 accelerators

Simple Questions: (each one counts 1 point, total 53 questions/points)

1. Neutron dose equivalent (mSv) outside field per photon Gy at isocenter for 20MV beam. 1.0~1.6 mSv/Gy
2. Scatter and leakage shielding thickness calculations are equal. The shielding that should then be used is: A TL + 1HVL, B other options including Ts + TL, Ts + 1TVL.
3. Parts definitely not included in EPID – options were ion chamber, CCCD camera, mirror, silicon screen, some other dose detection device. liquid
4. TBI – what is not true – A. Dose Uniformity < 15%, B. Tissue Equivalent Compensators are used, C. High SSD, D. AP preferred over lateral, E. Lower dose conformity with increased energy. high E, better uniformity
5. S/rho and rho given for lead. Calc thickness of lead used to shield 20MeV beam. $(S/\rho)\cdot\rho = S \rightarrow$ MeV/cm $\Rightarrow$ (20MeV)/(S MeV/cm) = (20/S) cm.
6. How many TVL's in a linac head? 3 TVL ⇒ 0.001
7. PDD for wedge increases over open field due to: A. Photon interactions in the wedge B, C, D, E…..
8. 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. +no purpose reduce charge leakage
9. 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 …
10. Why does the equivalent square technique work? A. Because scatter doses are equal between square and rectangular fields. Other options involved statement about collimators and scatter that sounded wrong ?
11. TG51: what's upper limit for Pion? 1%, 3%, 5%, 10%.
12. TG51: where is cylindrical chamber's center placed for photon beam calibration? d=10cm, photon; d=dref electron; No shift
13. TG51: to cross calibrate parallel-plate chamber, what should use? Co60, high energy photon, high energy electron, low energy electron.
14. TG51: KQ depends on what? (choices included beam energy, ion chamber, both) both.
15. TG51: What's energy specification for electron beams? most probable energy $E_0 = C_1 + C_2 R_p + C_3 R_p^2$
16. TG51: total consecutive measurements were done with $\boxed{20\%}$ difference, the reason is: 100 SSD vs 100 SAD; etc.
17. TG51: where is the effective point of measurement of parallel-plate chamber? surface
18. How do you convert ionization curve to %dd curve? using stopping power correction of stopping power ratio of water to air
19. Agent used in PET? 18FDG
20. 9MeV electron beam. At 4 cm depth, how much lead should be used to shield deeper structure? No other information. 9MeV ⇒ Rp: 4.5cm. $E = 9(1-\frac{4}{4.5}) = 1$MeV ⇒ 0.5mm lead
21. Difference between physical wedge and dynamic wedge. Beam hardening. more MU?
22. IMRT: Difference between simulated annealing and gradient reduction in IMRT? Faster, more accurate in dose calculation in build up, better with step-and-shoot than with sliding window, achieve global minimum instead of local, etc.
23. IMRT: one fluence map is shown for 5 fields prostate IMRT, identify the field. AP, RPO, RAO, LAO, LPO.
24. Klystron's function.
25. Gas pressure low fault is related to which part in Linac? Gun, Waveguide, Magnetron, Accelerating tube, etc. ⇒ vaccumed!
26. Linac's outputs are off the same way for all the beams, what is the problem? klystron, bending magnet, RF waveguide, monitor chamber - I said monitor chamber because it would be the most consistent
27. What's PTV?

	TD5/5 whole	2/3	1/3	TD50/5 whole	2/3	1/3
kidney	2300	3000	5000	2800	4000	NA
brachial P.	6000	6100	6200	7500	7600	7700
optical nerve	5000			6500		
Lung	1750	3000	4500	2450	4000	6500

28. Which organ shows partial volume effect? Brachial Plexus, Kidney, Optic nerve, etc.
29. To compare light field vs. radiation field, film is used. Ask distances for SSD and film SAD. SSD=100, SAD=100; SSD=100-dmax, SAD=100; etc. According to Khan: film @ SAD plastic sheet thick enough to provide max electronic buildup
30. Photon field abuts electron field, where is the hot spot? photon
31. The Transport Index represents the exposure rate…. (choices included "on the surface" and "at one meter") @1m! on the external surface ⇒ 0.005mSv white; 0.5mSv Yellow-I; 2mSv Yellow-II; 10mSv Yellow-III
32. Mayneord's Factor is more accurate for: 6MV, 6x6, 110 SSD; 6MV, 30x30, 150 SSD; 15MV, 6x6, 110 SSD; 15MV, 6x6, 150 SSD; etc.
33. What "stereotactic" means in stereotactic radiosurgery ⇒ In Greek, "solid ordering" use 3D coordinate to localize small targets
34. TG43: what is Λ? dose rate constance (cGy/hr / U) @(1cm, 90°)
35. Tolerance for simulator laser vs. gantry center (or some other mechanical center)? 2mm; 2mm rotation center; coincidence of coll. gantry, couch axes with isocenter: 2 mm diameter

$\frac{PDD(f_2)}{PDD(f_1)} = \frac{TAR(d, r_{d f_2})}{TAR(d, r_{d f_1})} \cdot \underbrace{\left(\frac{f_2+d_m}{f_1+d_m}\right)^2 \cdot \left(\frac{f_1+d}{f_2+d}\right)^2}_{F}$

scattering effect

if $f_2 > f_1$, $TAR(d, r_{d f_2}) < TAR(d, r_{d f_1})$.

F errors if: low E, large field, large SSD change, large depth

depths of PDD — TG-40 2mm @ therapeutic depth

36. Amount of X-ray contamination of 18 MeV electron beam? 1%, 4%, 10%, etc.

37. IMRT shielding: how much more shielding needed? All wall + TVL; Primary + TVL; Secondary + HVL; Secondary + TVL; etc. if $C_I = 5$

?. 38. If you were going to use a thimble chamber to calibrate an Ir192 source what type of beam would need to be used in determining the calibration factor? Calibrate with 192Ir; Calibrate with 380 keV X-ray, Cobolt-60 etc.

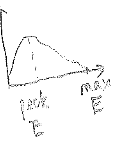
39. 45Gy photon treatment to neck. Choose electron energy for boost to treat nodes at 3cm depth and spare cord at 5cm depth. $R_p < 5cm$, $E < 10MeV$; $R_{90} > 3cm$, $E > 3 \times 3.8 = 9MeV$

40. Treat 4.3 cm depth with 12 MeV and 200 cGy, dose at dmax. $E = 12MeV$, $R_{80} = E/2.8 = 4.3cm$, $D_{dmax} = 200/0.8 = 216$ cGy

41. Multi detector CT, when cone beam increases size, what's true: Collimator decreases, scatter photon increases, etc. (not quite sure about the answers)

42. Shielding: What's peak energy of photons near door? 200 keV, 500 keV, etc. McGinley Page 45. the peak energy of X-ray spectrum at the outer maze opening is 0.2MeV

peak energy of spectrum ≠ max. energy



43. Shielding: Electron only machine has 4 electron energies, each with 3.5%, 2%, 1.5%, and 1% X-ray contamination. Workload 200 Gy/week, what is weekly workload for photon contamination?

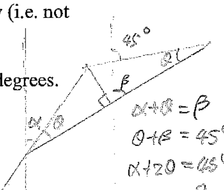
44. Decay rate of 192Ir per day. 1% per day

45. Weekly dose limit for unrestricted area. 0.02mSv/wk 0.02mSv in any hour

46. GM counter property. ⇒ high sensitivity. but has quenching issue. slow recovery time

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

48. 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? $RPO(G) = 180° + 33° = 213°$



$\alpha + \theta = \beta$
$\theta + \beta = 45°$
$\alpha + 2\theta = 45°$
$\alpha = 45° - 2\theta$
$= 45° - 2 \cdot \tan^{-1}(\frac{10.5}{700})$
$= 33°$

49. Difference between Acceptance Test and Commission of Linac.

50. Tolerance for deviation in a light field for a CT sim? conventional Sim. 2mm or 1% Light vs. rad.

51. How much dose is given for an I-125 seed 1.44DoT1/2(1 - e^ln2/t1/2*t)

?. 52. What is the dose rate at 1m from a patient receiving external beam treatment (consider 90° scattering ⇒ 0.001 × D

?. 53. If the high voltage power source is pushing too much, what is the most likely observed result on the accelerator.

54. Which modality (photons or electrons) and energy is used to cross calibrate a parallel-plate chamber with a cylindrical chamber. e⁻. higher energy

wedge angle:
the angle between wedge isodose line and a line ⊥ to C.A.X of beam at depth of 10cm.
(not 50% isodose ← old definition)
⇒ because at greater depth, the isodose angle become smaller because the increased scatter will reduce the wedge effect.

→ use R_{50} calculate R'_{50} or look up table

55. Electron beam quality is specified by (R50, Dref etc, dmax etc)

56. Given a table of PDD's 4 MV and 18 MV what is the ratio of max dose 4MV/18MV.

57. Effect on point outside treatment field when using dynamic wedge versus hard wedge. No beam hardening, longer beam on time → more scattering, leakage to area that is not intended to tx. ? where I found this ?

According to Varian: dose to peripheral area: EDW < physical wedge

Complex Questions: (each one counts 3 points, 27 questions, and total points 81)

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. What is the ratio of dwell times 1 to 2 to make dose A equal dose B?

2. 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? $D_c = 62 + 150 = 212cGy$ $D_c' = 212 \times 0.18 = 38.16cGy$
$38.16x + 212 \cdot y = 4000$. $200 \times (x+y) = ?$

3. A lead pig with 2 cm wall thickness is inside a 30cm diameter polyurethane foam shipping drum. HVL of lead was given (=5.5mm). Exposure rate constant of 192 Ir was given (0.32 mR/mCi hr at 1 meter). Calculate max activity to keep exposure rate below 50mR/hr on the drum surface.
$(X mCi) \cdot (0.32 mR/mCi\,hr)\, \exp(-\frac{\ln 2}{5.5} \times 20) \times (\frac{100}{15})^2 = 50 mR/hr \Rightarrow X = 43.70 mCi$

4. TBI, diode reading 450cGy on surface, prescribed midline 600cGy POP laterals, 30cm separation. TMRs were given with 350cmSSD. What is error in midline dose? A. 2.6% higher, etc.

5. Three isocentric beams 120 deg apart, AP and post obliques. Each goes through 15 cm depth to isocenter. 180Gy at isocenter weighted equally for three beams. Post beams transfer 9cm lung (electron density= 0.33), TMRs given at 3,6,9,12,15 cm. Calculate MU(post obliques)/MU(AP).

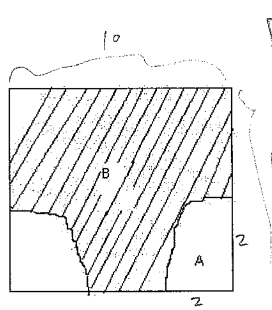
6. Ratio of Maximum Dose between 25MV and 4MV for same dose to midline using POP setup with SSD =100cm. PDD's given.

7. Given Kersey's formula and the distances and ratio of maze areas, neutron dose at isocenter (mSv) per photon cGy at isocenter, what is neutron dose (mSv) at door per photon cGy at iso. Told TVL of maze for neutrons is 5m. $H_{n,D} = (H_0)(\frac{S_0}{S_1})(\frac{d_0}{d_1})^2 10^{-(\frac{d_2}{5})}$ $d_0 = 1.41m$ where H_0 is measured

8. HDR 192Ir. Patient treated with time 420sec with Activity 3.75Ci on Aug 1st. Source got replaced with activity 9.43Ci on Aug 16th. Calculate treatment time on Aug 21st. No 192Ir half life given. $3.75 \times 420 = 9.43 \times \exp(-\frac{\ln 2}{73.8} \times 5) \cdot T \Rightarrow T = 175$

9. Given dose to point A 200 cGy, calculate thickness of block to achieve point B dose 90 cGy. TMR, %DD, and HVL given, depth may be different for B.

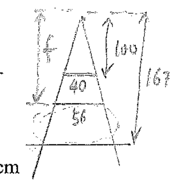
$D_A = D_C'$
$= (DR \cdot mu) \cdot TMR(2\times2, d)\, Sc(10\times10)$.
$D_B = D_{open} - (1-TF)\, D_{block}$.
$= D_{open} - (1-TF) \cdot DR \cdot mu \cdot TMR(8\times8, d) \cdot Sc(8)$
$= (DR \cdot mu) \cdot TMR(10\times10) - (1-TF)(DR \cdot mu)\, TMR(8\times8, d)$



$n_{pb} \cdot 2 + (6 - n_{pb}) \cdot 18 \le 36$.
$\Rightarrow n_{pb} \ge 4.5$

10. 36 inch space is available for 6 TVL shielding. Given Pb TVL (2 inch) and Concrete TVL (18 inch), what is the minimum thickness of Pb needed? $4.5 \times 2 = 9$ inch

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



12. Field size is measured 56 cm on patient skin and collimator 40 cm with table at its lowest position 167 cm from the source. What's patient size (including setup bag etc.)?
$\frac{100}{f} = \frac{40}{56} \Rightarrow f = 140$ thickness $= 167 - 140 = 27$cm.

? 13. Given diagram of one dimension blocked field with distance from CAX and table of SARs (0cm 6cm 9cm 10cm etc), calculate SAR. (| | Block | |)

14. Superficial X-ray, 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? $\frac{150}{52.3} = \left(\frac{f+d_m+10}{f+d_m}\right)^2 \Rightarrow f+d_m = 14.49$cm.

15. Dose to cord from AP/PA 100 SAD setup. Given 22cm separation, cord 4cm deep, and 200cGy to isocenter. AP: $D_{mp} = 100 = MU \cdot Sc \cdot Sp(r) \cdot TMR(r, d=11) \cdot \left(\frac{100}{100}\right)^2$ PA: $100 = MU \cdot Sc \cdot Sp(r)\, TMR(r, d=11)$
$D_c = MU \cdot Sc \cdot Sp(r \cdot \frac{107}{100}) \cdot TMR(r \cdot \frac{107}{100}, d=18) \cdot \left(\frac{100}{107}\right)^2$ $D_c' = MU \cdot Sc \cdot Sp(r \cdot \frac{93}{100}) \cdot TMR(r \cdot \frac{93}{100}, d=4) \cdot \left(\frac{100}{93}\right)^2$

16. Film exposed for dosimetry. Given transmitted light is 200 times smaller than original, what is the dose? OD vs dose table was given. $OD = \log(T) = \log 200 =$ $D_{cord} = D_c + D_c'$

17. Single field 125 cm SSD, 4x17. 300cGy was prescribed to 5cm deep. Given PDD table and TMR table, calculate MU. No Output factor vs. field size! No machine calibration condition, SSD or SAD!
$\frac{2\times4\times17}{(4+17)} = 6.5$ (SSD)
$MU = \frac{300}{Sc \cdot Sp \cdot TMR(6.5 \times \frac{125.5}{125}, d=5) \cdot \left(\frac{100}{125.5}\right)^2}$ or $\frac{300}{Sc \cdot Sp \cdot PDD(6.5, f=125, d=5) \left(\frac{100}{125+d_m}\right)^2}$

18. 15 x 20 POP, calculate MU for dose required. No Output factor vs. field size! No machine calibration condition, SSD or SAD!

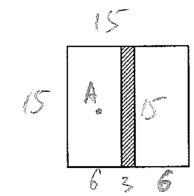
? 19. Multiple beams plan: AP weighted to 100% at dmax, laterals weighted to 100% at dmax. 200 cGy delivered to 238% isodose line. What is the dose delivered by AP beam?
$200/238\% \Rightarrow 100\% = 84$cGy. $D^{AP}_{dm} = 84$cGy $D^{AP} = D_{dm}^{AP} \cdot PDD(f=f', r, d)$

20. Given readings at 10 cm depth for 10 x 10 and 20 x 20 fields with 100 cm SAD, and two TMRs, calculate the Scp(20).

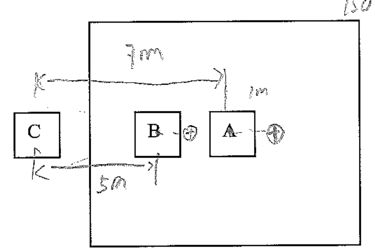
21. 15 x 15 field with 3 x 15 block in the center, which has 5% transmission factor. Depth at 7 cm, dose to point A given with 1.01 OCR, calculate dose to CAX under block, given table like:

$D_1 = (DR \cdot mu) \cdot Sp(10) \cdot TMR(10\times10) \left(\frac{100}{100}\right)^2$
$D_2 = (DR \cdot mu) \cdot Sp(20)\, TMR(20\times20) \left(\frac{100}{100}\right)^2$
$\Rightarrow \frac{D_2}{D_1} = \frac{Sp(20) \cdot TMR(20\times20)}{Sp(10) \cdot TMR(10\times10)}$
$\Rightarrow Sp(20) = \frac{D_2 \cdot Sp(10) \cdot TMR(10\times10)}{D_1 \cdot TMR(20\times20)}$

FS	5, 7, 10, 15, 20
OF	
TMR(7cm)	
%dd(7cm)	

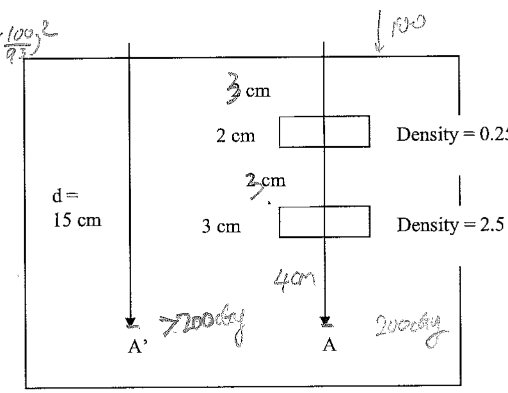


22. Point A and B are candidates for machine isocenter. Point C is outside the primary shielding and distances AC(=7m) and BC(=5m) are given. If isocenter is set at A, measurement at C is within the MPD specification. If isocenter is changed to B, how much more shielding (TVL) is needed for the wall to maintain same reading at C, given TVL.



ISO @ A: $D_C = (WUT) \cdot B / (d=8)^2$
ISO @ B: $D_C' = (WUT) \cdot B / (d=6)^2$
$D_C'/D_C = \left(\frac{8}{6}\right)^2 = 1.778$.
To get the same $D_C' = D$.
$B' = \frac{1}{1.778} = 0.5624 \Rightarrow n_{TVL} = 0.25$

23. From source to point A, there are: 100 cm SSD to surface, then 3 cm tissue, 2 cm inhomogeneity (ρe=0.25), 3 cm tissue, another 3 cm inhomogeneity (ρe=2.5), finally 4 cm tissue. So depth is 15 cm. 4MV beam delivers 200 cGy to point A with inhomogeneities. What's the dose to point A without the inhomogeneities? TMRs were given.



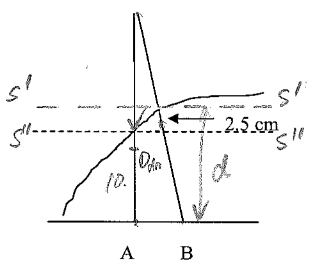
TMR_ratio:
$d_{eff} = 3 + 2\times0.25 + 3 + 3\times2.5 + 4 = 18$cm
$CF = \frac{TMR(d=18, r@15cm)}{TMR(d=15, r@15cm)} < 1$
$D_A' = D_A / CF = 200/CF$.
$CF = \left(\frac{D_{w/Inh}}{D_{w/o\,Inh}}\right) \Rightarrow$ check!

W $\quad d \quad T=1 \quad B = \frac{Pd^2}{WUT} \quad P = 0.02\,mSv/wk$

24. Given primary workload, distance to office, and TVL, calculate shielding thickness to achieve 1/10 of MPD. U, T, MPD were not given. $\frac{1}{10} P = 0.002\,mSv/wk$

Assume $U = 1/4 = 0.25$

25. If dose to point A (depth 10 cm) is 200 cGy, calculate dose to point B ignore beam divergence. %DD(10)=65%, %DD(12.5)=56%, 100 SSD alone CAX.



In this case $h = -2.5$

SSD = 100 cm @ C.A.X.

$d = 12.5$ alway defined at point surface

$D_B = D'_{dm} \cdot P'$

$D_e = D_{dm} \cdot P_{corr}$

$P_{corr} = P' \cdot \left(\frac{D_{dm}'}{D_d}\right)$

$= P'\left(\frac{SSD+dm}{SSD+dm+h}\right)^2 = P'\left(\frac{100+1.5}{100+1.5-2.5}\right)^2$

$= \%DD(12.5) \cdot \left(\frac{100+1.5}{100+1.5-2.5}\right)^2$

P' is always relative to surface at $S'-S'$

$P'(d) = P'(12.5)$

For TMR/TAR:

$CF = \frac{T(d, r_A)}{T(d+h, r_A)} = \frac{T(12.5, r_A @ d=12.5)}{T(12.5-2.5, r_A)}$ (<1)

P'' relative to $S''-S''$

$P'' = PDD(10) = 65\%$

$P_{corr} = P'' \cdot CF$

26. Lung correction given dose with no correction - the corrected dose has 2 cm of lung and 4 cm of dense medium (4x tissue) - what is the dose at that second point?

6MV: -2.5%/cm lung $\Rightarrow (-2.5\%) \times 2 + (2.5\%) \cdot 4$

$+2.5\%$/cm bone $= 5\%$ less dose

27. Orthovoltage shielding calculation given the workload.

or using TMR

$d_{eff} = 2 \times 0.25 + 4 \times 4 = 16.5$

$d = 2 + 4 = 6$

$\Delta d = 10.5$ cm

6MV 3.5% /cm for attenuation.

$3.5\% \times 10.5 = 36\%$

28. What would cause the biggest change of the depth of the 80% IDL for a 9 MeV electron? (choices included: add 1 cm bolus, change to 18 MeV, increase FS)

$R_{80} = \frac{9}{2.8} = 3.21$

e' ⇓ change by 1cm

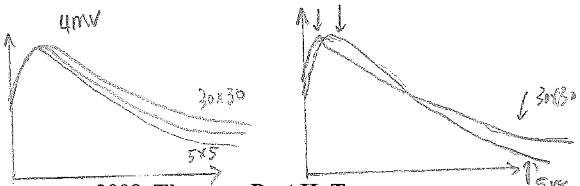
⇓ $R_{80} = \frac{18}{2.8} = 6.42$

change by 3cm

General Observations:

- Shielding questions -- lots of them!
- Lots and lots of dosimetry calculations:
- If you have the PDD or TMR data, how many MUs required?
- Know when to use Mayneord F factor and when to ratio TMRs
- Know relative depth doses for all electrons and photons
- Know definition of terms in TG-51:
- Numerous gap calcs
- Lots of SSD and SAD treatments, max dose, midplane dose.
- One or two, electron beams problems. Not too many. All the fields were rectangle and you had an additional calculation to convert to the equivalent square. TG 51 questions but not difficult. Raphex is very good for the easy questions and Khan and McGinley are good for the others. Lots of practice with the windows calculator. Some problems with long sets of calculations.

Dmax ↓ for large field size



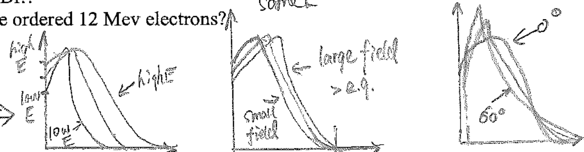
For photon beam PDD with field size, E. see review course notes

2008_Therapy_Part II_Type

- Which scanairo would you most likely talk to the Dr.?

A. if he had a small cut-out to place on the skin and he ordered 12 Mev electrons?
B.
C.

- Which curve represents 18 Mev , 6x6 FS $\Longrightarrow$ E



oblique angles Dm ↓ PDD shift upstream

R_{90} ↓ with small field size (more significant for high E)

- Had several curves, asked to select which one was 6x6 from field sizes of 4x4, 6x6, 10x10 or 12x12

surface dose → Ds ↑ with small field size

Rp remain constant

- Orders for 30 fractions, AP/PA, 180cGy/fx SAD. When will the cord dose reach 4500cGy?

TAR PDD and TMR tables given, Separation is 12 cm, Cord is 5cm posterior

20fxs
24fxs
26fxs
28fsx

- What is the dose for irreparable damage to the kidney?

1000cGy
2000cGy
3000cGy → ?
4000cGy

$TD_{5/5}$ whole: 2300 2/3: 3000 1/3: 5000

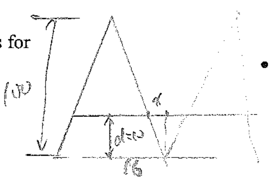
$TD_{50/5}$ whole: 2800 2/3: 4000

- Two isotopes Pd (lamda = .016) (rho =) and I125 (landa = .)(rho =) half life is 17 days for Pd and 60 days for I125. After 120 days what is the ratio of doses?

$D = \dot{D}\, T_{avg}\left(1 - e^{-\frac{\ln 2}{T_{1/2}} \cdot t}\right)$ $T_{avg} = T_{1/2} \cdot 1.44 = \frac{\ln 2}{\lambda} \cdot 1.44$

- Monte carlo calculations stop calculating at what energy and bundles everything into one

10 kev → no contribution to dose
100 kev
200 kev ⇒
500 kev
1 Mev



$gap2 = \frac{16}{100} \times 10 \times 2$

$= 3.2cm$

- How often according to TG40 should the wedge latch be checked? Monthly

- What are Monte Carlo space files???

A. It registers where electrons are in space for calculation???????
B.

- A picture of a DVH
- Shows critical organs, PTV and GTV curves. Choose which curve represents the GTV

- 13.05 nC exposure, (W/e = 33.3J/C) 2.58 x 10 R/C What is the volume of gas in the chamber?

$X = \frac{Q}{m} \Rightarrow X = \frac{Q}{\rho \cdot V}$

Assume 1R delivered

$1R = 2.58\times10^{-4}\, C/kg = \frac{13.05\times10^{-9}\,C}{1.29\,kg/m^3 \cdot V(m^3)}$

$\Rightarrow V = \frac{13.05\times10^{-9}}{2.58\times10^{-4}\times1.29} = 3.92\times10^{-5}\, m^3 = 3.92\times10^{-5}\times10^6\,cm^3 = 39.2\,(cc)$

- TG51 calculation. You have to calculate Ppol, Pion and TPC (in kPA). Mraw high and low given, everything given.

- What is the range of a Y 80 beta 2.2Mev in air?

10 cm
20cm
100cm
200cm
400cm

$Sr^{90} \to 0.5\,MeV \Rightarrow$ 200cm

Y^{90} ↓ 3.6m x 2.2 MeV = 800cm. No answer match!

- Effective energy of an electron Ez 4 Mev, depth is 1.7cm and an Eo is7.1 Mev Two energies given.

$E_z = E_0\left(1 - \frac{z}{R_p}\right) \Rightarrow 4 = 7.1\left(1 - \frac{1.7}{R_p}\right) \Rightarrow R_p = 3.89cm$

- Picture of squares, 3cm, then 2 cm then 1 cm which equals tissue, bone and air. What is the effective depth when the beam is directed through each material.

$3 \cdot \rho_{tissue} + 2 \cdot \rho_{bone} + 1 \cdot \rho_{air}$

- A universal wedge has a 0.65 wedge factor. A 60 degree wedge is needed. 100 Mu are given for open and 200 Mu given for the wedge field. What is the average WF?

$W_O + W_W = 1$ $\frac{MU_W}{MU_O} = \frac{W_W}{W_O \cdot WF} \Rightarrow \frac{200}{100} = \frac{W_W}{W_O \cdot 0.65} \Rightarrow W_W/W_O = 1.3$

$W_W = 0.565$ $W_O = 0.435$

$WF = \frac{WF}{W_O \cdot WF + W_W} = \frac{0.65}{0.435\times0.65+0.565} = 0.767$

- Overall uncertainty according to TG40? 6%, 5%, 4%, 3%

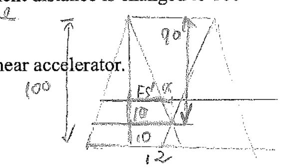
⇒ overall dosimetric uncertainty ±5%

overall spatial uncertainty ±5mm ⇒

- If the collimator rotation is off 1.2mm, the couch rotation is off 1.4mm and the gantry rotation is off 1.5, according to AAPM what is the overall uncertainty?

$\sqrt{1.2^2 + 1.4^2 + 1.5^2} = 2.38mm$

- Gap calculation: SAD 90 depth =10, FS = 24cm , but the treatment distance is changed to 100 SAD, d=10, FS=32cm Assume two fields are the same



$FS' = \frac{80}{90} \times 12$

$\frac{x}{10} = \frac{FS'}{80} = \frac{12}{90} \times 10 =$

$gap1 = 1.2 \times 2 = 2.4cm$

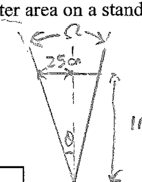
- Calculate the steradian of a 50cm diameter area on a standard linear accelerator.

a. .137
b. .122
c. .187

$\Omega = 2\pi(1 - \cos\theta)$

$= 2\pi\left(1 - \frac{1}{\sqrt{1^2 + 0.25^2}}\right)$

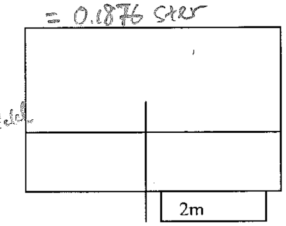
$= 0.1876$ ster



⇓

0.122 ster for 40x40cm² field

Page 185 in McKinley's book



- HDR shielding question. How much thickness for 10 patients per week, 5 days a week, 500cGy/patient. The drawing showed a distance of 2 meters (I think that's what it meant).

day

should be @1cm.

$W = 500cGy \times 10 \times 5 = 25000\, cGy/wk$ ⇐ wrong!!!

$B = \frac{Pd^2}{WUT}$

$t = \frac{10 \times 5 \times 5Gy}{(1Gy/min)} = 250min$

$W = \Gamma \cdot f \cdot A \cdot t = 4.69\, Rcm^2/hr \cdot (10\times10^3 mCi) \cdot 0.96 \cdot \left(\frac{1}{100}\right)^2 \cdot \frac{250}{60}$

$= 18.76\, cGy/wk$ @ 1m

U = 1 for HDR

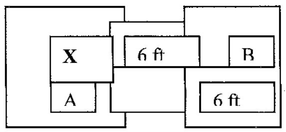
T = ? According to area

P = 1mSv/wk occupation <2mR/hr

0.1 mSv/wk public or 0.02mSv/wk more conservative cooling system

gantry: accelerate guide, bending magnet, accelerate solenoid, primary coll., energy slit, target

stand: klystron, klystron solenoid, circulator, rf driver, rf load, pulse transformer



Vaccume system: klystron, electron gun, accelerate guide, bending magnet.

IMRT only increase leakage radiation

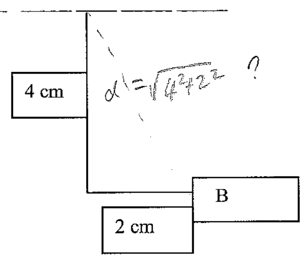
$S = (\frac{S}{\rho}) \cdot \rho$

$d(cm) = E/S$

80 Gy to triangl

- For an instantaneous exposure it gives 30 mR. If a secretary is sitting at point B and the wall is shielded for 6X how many patients a week can be treated for a weekly dose of 0.02mSv? ⇒ more details in next page.
- Shielding question that gives a thickness of concrete and the room is shielded for 6X. How much more shielding is required for 18X? $\left[\left(\frac{thickness}{TVL_{6MV}} \right) \cdot TVL_{18X} - thickness \right] = \left[\frac{th}{37cm} \times 45cm - th \right]$
- Why do the doctors leave a strip around each side of the treated area on a sarcoma?
A. for lymphatic drainage ?

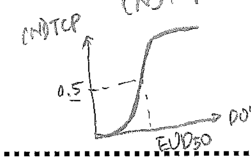
?



$d' = \sqrt{4^2 + 2^2}$?

dose which if distributed uniformly across the entire target/organ at risk, causes the same biological effect as actual inhogeneouse dose distribution

$(N)TCP = \frac{1}{1 + \left[\frac{EUD_{50}}{EUD} \right]^{4\gamma_{50}}}$



- What is the dose to point B?

1. Range of Sr90 in air 0.5MeV ⇒ 3.6m × 0.5 = 180cm
2. Universal Wedge, WF = 0.2, what % MU needed for 30 degree effective wedge $W_N = \frac{\tan\theta_{eff}}{\tan\theta}$
3. What does a fMRI measure → physiology T_1, T_2, tissue magnetic relaxtion
4. What is primary purpose of a bending magnet?
5. 1 R delivered, 3x10-10 C measured… what's the size of the chamber? ⇒ see previous page.
6. 30 cm2 field directed at roof, what is sold angle subtended at a point on the ground?
7. HDR Cylinder with 5 sources 1 cm apart. Point A is midline, 4 cm from sources and receives 200 cGy. Point B is 2 cm lateral to Point A. What is Point B dose?
8. Increasing the current to the magnetron does what?

what is θ for universal wedge?

change direction of e⁻

Solid angle (Ω) $= 2\pi(1 - \cos\theta)$ unit (steradians)

magnetron power output change in electron beam change in output energy shift

⇒ ↑ magnetic field ↑ peak power out ↑ efficiency

Page 90 Carzmark book

A 4cm B Do 1 1cm 2 3 4 5

Assume same dewell time

$D_A = D_0 \left(\frac{1}{\sqrt{2^2+4^2}} + \frac{1}{\sqrt{1^2+4^2}} + \frac{1}{4^2} + \frac{1}{\sqrt{1^2+4^2}} + \frac{1}{\sqrt{2^2+4^2}} \right)$

$D_B = D_0 \left(\frac{1}{\sqrt{5^2+4^2}} + \frac{1}{\sqrt{4^2+4^2}} + \frac{1}{\sqrt{3^2+4^2}} + \frac{1}{\sqrt{2^2+4^2}} + \frac{1}{\sqrt{4^2}} \right)$

primary barrier will be more than adequate to shield against scatter radiation, leakage even with IMRT

↑ In NCRT Page 115 example.

$B_L(\text{no IMRT}) = \frac{P d^2 \, 0.001}{W T}$

$B_L(IMRT) = \frac{P \cdot d^2 \cdot 0.001}{W' \cdot T}$

$\frac{B_L(IMRT)}{B_L(\text{No-IMRT})} = \frac{W}{W'} \Rightarrow \log[B_L(IMR)] = -\log\frac{W}{W'} + \log B(\text{No-IMRT})$ ↳ $+ \log \frac{W_{IMR}}{W_{\text{No-IMRT}}}$

9. Retrofit a linac to perform IMRT… how much shielding do you need to add?
10. What is the source of electrons in an electron treatment?
11. Given density of lead and mass atten coef for a random energy… what is TVL?
12. You check the source strength from the vendor 2 weeks after receipt. Given calibration factor, and reading… how far is the vendor off?
13. Given DVH curve… which curve has the least homogeneous dose?
14. Given DVH curve… points to a line, what is it? Answers were PTV, GTV, OAR, Volume receiving 100 of dose
15. SRS treatment, 4mm cone… what is max dose? Answers were 10 Gy, 20 Gy, 40 Gy, etc
16. All readings, voltages, kq, Nd,w, temp & pressure… how many cGy per MU?
17. You calibrate a machine with the outside temp and press…. But this is the inside temp and press… how far off is your output?
18. Treating with parallel opposed wedge fields for 60 Gy in 30 fxs and the MU per beam in 160 MU. After 10 fxs… realize WF was not in calc. How many MUs required for remaining 20 fxs to get to 60 Gy?
19. Electron Eo = 7.1 Mev, mean E at 2 cm = 4 Mev… what is range?
20. According to TG51… you need to adjust you %DD by what?
21. What happens to surface dose and %DD by adding a physical wedge? surface dose ↓ %DD↑
22. Three layer material. First layer is 3 cm thick, HU = 0. Second layer is 4 cm thick, HU = -800. Third layer is 2 cm thick, HU = -100. What is effective depth?
23. Why cant MRI be used for hetero corrections? ⇒ No electron density
24. Why should you convince the doctor to not use a 25 cm x 3 cm electron cutout?
25. You have a half beam 6 MV photon beam and a parallel 9 Mev electron that match on skin surface… where is hot spot? photon
26. What is definition of EUD? → equivalent uniform dose
27. What is definition of integral effective dose? → total energy absorbed in treated volume.
28. What part of curve is an ion chamber used for calibration operated in? saturation
29. Why would a doctor use Pd103 instead of I125 for prostate implant? short half-life. fast delivery biological advantage
30. Which part of linac is not water cooled?
31. Given an axial cut with weird dimensions drawn all over it… had to determine LPO angle? Easy geometry
32. Probably 10 MU calcs that I thought were very hard.
33. Probably 5 or 6 TG43 brachy physics calcs
34. According to TG40… how often do you check wedge interlocks?
35. Probably 5 or 6 shielding calcs.
36. You use a 3x3 electron cutout… what doesn't happen? Dmax decreases, output decreases, flatness decreases, range decreases NO
37. Probably 3-4 questions where you had to know that Total Dose = 1.44 times Half Life time Initial Dose Rate

Integral dose

1. giving a dose rate constant of I125 (Ir192?) measured experimental 0.7, two numbers calculated by Monte Carlo method (0.64, 0.67), something like that, ask according to TG-43, which one to use in planning system, 0.64,0.67,0.7,0.65 (the experiment one, one of the Monte Carlo one, or the average of the two Monte Carlo) ⇒ $con\Lambda = [Exp\Lambda + mc\Lambda]/2$ ⇒ $con\Lambda = \left[0.7 + \frac{0.64+0.67}{2} \right] / 2 = 0.6775$
2. The universal wedge question like the one we had in the old exams, given a universal wedge, wedge factor= 0.25, to make a 30 degree wedge, what's the MU ratio of the wedge field and open

$(n \cdot 5) \cdot 30s/_{3600s/hr} \cdot 0.6 mSv/hr \cdot \left(\frac{6}{12}\right)^2 = 2mSv/wk$

$n = 320$

field. I didn't know we need to assume the universal wedge angle is 60 degree until today, I thought something is missing in this question when I was working on it from the old exams.

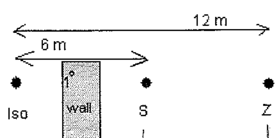
3. one of the shielding questions like the old one, an office will be add next to the storage room, distance to the point in storage room from the source is 6meters, to the point in office is 12meters, the reading in the point at storage room is 0.6mSv/hour, how many patient can they treat per week to get less 2mSv/week in that point in the office, the barrier between storage room and office has no attenuation, beam shoot on the barriers only 30s per patient, clinic is running 5 days per week. somehow I just can't get a number close to one of the answers.

4. Some of the questions have the answers are very close, I remembered one of the TG-51 calculation questions, the answer is like, 0.62,0.63,0.64...something like that, I got the answer is like 0.624 first time.

****

1. TG-51 calc. Given raw data. Need to calculate Pion and Ppol. Need to know standard pressure in kPa. Find dose at isocenter if 100 MU were given. Also given rcav which I didn't use. ↳ 101.3kPa = 760mmHg
2. Shielding –lots.
3. HDR calculation using point source formalism from TG-43 (given dose rate constant, radial dose function, some other stuff)
4. ? ⇐ Treating a stereotactic lesion in the head with a 4 mm diameter beam. What is the largest dose you can prescribe?
5. Standard Gap Calc between a treatment with an SSD setup and a treatment with an SAD setup. Answer was 1.95 cm gap on skin. Options included 1.9 cm and 2 cm. I chose 2.
6. Photon and electron field
7. Concrete is used for neutron sheilding for what reason? (thermalizes neutrons was my answer) high hydrogen increase thermal neutron capture
8. Using lead and concrete to shield Primary wall. From the inside, what is the order of the materials? (lead then concrete, concrete then lead, other combinations) ⟶
9. Given 125I half life of 59.4 days, given exposure rate constant in cGy/hr/U or cGy/U/hr. After 30 days what is the dose rate to the tumor in mSv/hr?
10. 200 keV beam. The density of copper is given in g/cm^3, and the μ/ρ for copper is given in cm^3/g. If 3 mm of copper attenuates the beam to 63% of its original intensity, what is the TVL for copper? $0.37 = e^{-\mu \cdot 3mm} \Rightarrow \mu = 0.33 \Rightarrow 0.1 = e^{-0.33 \cdot TVL} \Rightarrow TVL = 6.98mm$
11. Shielding: the distance from isocenter to point S is 6m, and iso to point Z is 12m. Point S is in a store room and point Z is in a room being considered as new office space. A survey meter measures 0.2? cGy/hr at point S. A beam is aimed toward this primary wall for 30 seconds per treatment. For a maximum dose of 0.08? cGy/week at point Z, what is the maximum number of patients you can treat per day? Consider only photon interactions.

calculate from TG-43.
⇓
$\dot{D} = \dot{D}_0 e^{-\frac{\ln 2}{T_{1/2}} t}$
$D_c = \dot{D}_0 1.44 T_{1/2} (1 - e^{-\frac{\ln 2}{T_{1/2}} t})$

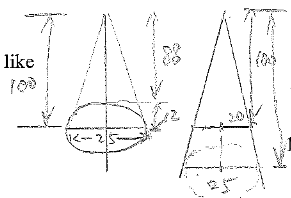


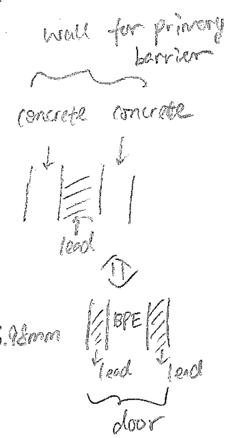
0.2cGy/hr

$0.2 \times \frac{1}{4}$
$= 0.05 cGy/hr$

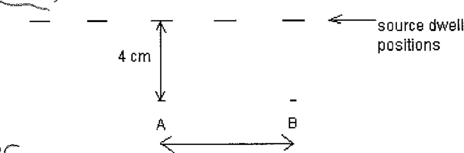
$D = (0.05 cGy/hr) \cdot \frac{30s}{3600s}$
$= 4.167 \times 10^{-4} cGy/tx.$
$D_{max} = (0.08 cGy/wk) / 7 days$
$= 0.011 cGy/day$
$n = D_{max}/D = 26.$

$0.06 \times \frac{1}{4} = 0.015 mSv/hr$
$0.015 mSv/hr \times \frac{30s}{3600s} = 0.000125 mSv/Tx$
$0.02 mSv/wk / 5 = 0.004 mSv/day$ ⇒ pt = 32 day



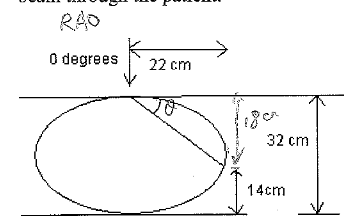


12. Given 5 HDR sources. 1 cm between each source dwell position. 4 cm between middle source and point A. The dose at point A is given. What is the dose at point B. Equal dwell times for all sources. (Also given source active length which is less than 2*distance, so I treated as pt sources)



$f' = \frac{25}{20} \times 100 = 125$
$SSD' = f' - d = 125 - 12 = 113cm$

13. A setup calls for a 25 cm field length at 100 SAD. The SSD is 88 cm. However, the field requires a wedge that has a field size limit of 20 cm at isocenter. What must the new SSD be in order to accommodate the wedge?
14. Find the RPO angle given the following (diagram). The line represents the central ray of the beam through the patient.

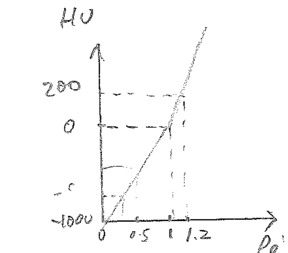


$\theta = \tan^{-1}\left(\frac{18}{22}\right) = 39.3°$
$Gantry = 90° + 39.3° = 129.3°$

15. Parallel opposed fields with equal weighting. 60 Gy in 30 fractions is prescribed to the isocenter. The fields are equally weighted. (SAD setup with iso at midsep). The patient separation is given, as well as the depth to the cord. The TMRs at three different depths are given. Find the maximum number of fractions that can be given with the limitation being the cord tolerance dose. ⇒ find D_{cord} per fx ⇒ $4500/D_{cord}$ = fx
16. Memory foggy on this one: You measure a brachy source and get a measurement in air at 1 meter of (given)R/S. The chamber volume is given, the chamber calibration factor is given (in cGy/C?). You are given the density of air in kg/m^3. The stated activity from the manufacturer is given. Given 0.876cGy/R, given 33.95 J/C, NOT given 2.58E-4 C/Kg = 1R. What is the relationship between your measured dose rate and the dose rate stated by the manufacturer?

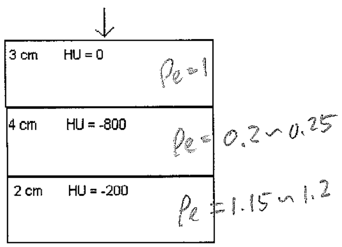
$D = X(R) \cdot f(cGy/R)$
$= \frac{Q(C)}{m_{(\rho \cdot V)}} \cdot f$

17. For a photon skyshine calc, What is the solid angle of a circular beam with a 50 cm diameter? (0.187)
18. A beam travels through tissue (see diagram). What is the radiographic depth?



slope $= \frac{1000}{1} = 1000$

$-800HU = 1-0.8 = 0.2$



W

$W' = 0.5W + (0.5W)\cdot C$

$= 0.5W + 0.5W \times 5$

$= 3W$

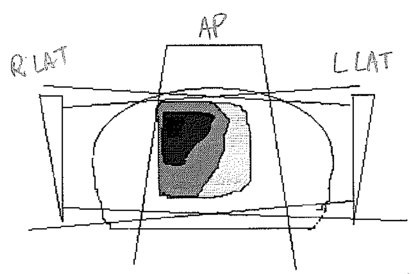
$\Rightarrow TVL = \log \frac{W'}{W} = (0.48\ TVL)$

19. A Shielding calculation was performed assuming no IMRT. If you will now be doing 50% IMRT, how much additional shielding will you need to add?
20. A universal wedge with a wedge factor of 0.25 is used to deliver a beam with and effective wedge factor of 30 degrees. What is the fraction of MU's delivered by the wedged portion of the field. (There were 2 questions like this. For this question, I tried using both the Tatcher universal wedge equation and the equation from Greene and Williams (Linear Accelerators for Radiation Therapy). BOTH answers were in there. Maybe both will be counted as correct???
21. Shown a setup with AP, Lt Lat, and Rt Lat fields. The Rt and Lt Laterals were wedged. The isodose distribution looks like the picture below. Another picture with a uniform isodose distribution is shown. You must choose which field weights and wedge weights to change in order to make the picture below look like a uniform isodose distribution:
You are given a choice between answers like this:

RT LAT wt	LT LAT wt	AP wt	RT lat wedge	Lt lat wedge
decrease	increase	same	increase	increase

Wt R LAT ↓

WT AP ↓.

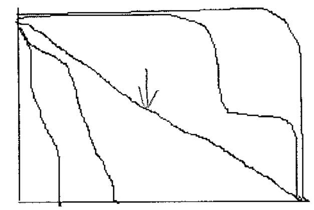


As a general rule, the risk of pneumonitis increase when
mean lung dose > 10 ~ 20 Gy
$V_{13} > 40\%$
$V_{20} > 25 \sim 30\%$
$V_{30} > 10 \sim 15\%$

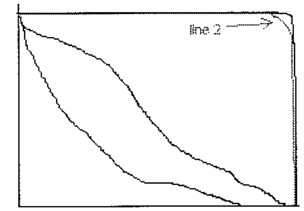
cathode

22. Electrons are produced in a linac by (thermionic emission from anode, thyratron anode, heating a filament, etc) emitted from cathode in electron gun
23. When the current in the magnetron increases: The magnetron voltage increases, other answers I can't remember.
24. Overall error expected according to TG-40
25. definition of QA
26. definition of wedge factor
27. Meaning of Equivalent Uniform dose (given a non-uniform dose distribution, find the uniform dose that gives the same biological effect)

28. Shown DVH and must choose the DVH line representing most heterogeneous dose distribution



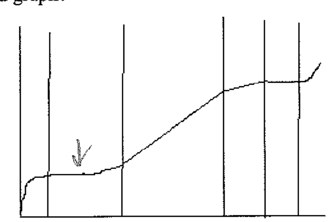
29. Which structure does line 2 represent on this DVH for an IMRT plan? (organ at risk, GTV, PTV, etc) It was an obvious PTV



when target is close to a joint, at least a part of the joint should be shield
A strip of tissue should be spared along the entire extremity, Delivering high dose to the entire circumference of extremity causes obstruction of lymphatic return → edema.

30. Why, when treating an extremity, do we block out a sliver of skin? (spare lympatic system, aid in skin healing after radiation, other choices)
31. When treating a lung tumor, what is the dose associated with radiation pneumonitis? (V20=30%, V50=10% etc) → 1mSv/Gy
32. Neutron dose from 15 MV photons: (2%, 5%, etc)
33. All of the following change when an electron beam is made significantly smaller by adding a cutout EXEPT: Rp dmax dose, etc.
34. When an electron beam has an oblique incidence on the surface, what happens? (how does it change dmax, Range, etc) (Khan p.321, 3rd ed.)
35. According to Bragg-gray cavity theory, the diameter of the air cavity should be (greater than the range of radiation in cavity, same as range of radiation in cavity, less than range of radiation in cavity – Khan p.114) ⇒ page 18 of review course
36. In which region would a cylindrical ion chamber be operated on a voltage versus ion pairs collected graph?

dmax ↓
Ddmax ↑
Rp ↑
↓ penetration (R_{80})
increase dose at shower depth



37. In Monte Carlo Treatment Planning Algorighms, what is the cutoff energy under which the path a particle will no longer be mapped discretely, and instead it will be lumped in with a general energy distribution function. (100keV, 10 keV, 1keV, two other options)
38. How much do shift your curve to get a PDD (PDI?) curve? Options included 0.6rcav upstream. It was the only one that made sense.
39. What is the purpose of the bending magnet. Options included: to accommodate a horizontal ~~waveguide~~, and to focus the electron beam on the target. accelarator guide
40. There was a question that required you to know that the bending magnet was NOT between the target and primary collimator. It may have been included in the previous question.
41. On fluoro images in the simulator, wires used toward the outer edges of the field of view can appear to be (farther apart?) than they actually are. This is due to: image intensifier, → ? magnification? automatic brightness control, scatter grid, another choice I don't remember.
42. A dose calc where you have SSD, Dose rate at Dmax for 100 ssd setup, and a depth of 10 (PDD given). For the given setup, they give you the MU required to give the dose. for the same dose delivered to an SAD field at a depth of 10 (They stated the TMR), how many MU's do you need? Need to do a back calculation to get the output factors that are not mentioned, then do the SAD calc and include the output factors.
43. Prescription is 200 cGy/day delivered by parallel opposed, equally weighted beams. They say they gave 147 MU per beam, but left out a wedge factor of 0.8 for the first 10 treatments. The patient is to receive 30 treatments total. What is the MU required (per beam) for the remaining 20 treatments in order to deliver the prescribed dose for the entire course of treatment? real $MU = 147/0.8 \approx 184$ MUs

20 cGy to add per fx: $MU^+ = \frac{20/2}{\frac{100}{147} \times 0.8} = 37$ MUs$/2 = 19$ MUs $\Rightarrow 203$ MU

$$MU = \frac{D_0 + \frac{D_0 \cdot n_1 (1-WF)}{n_2}}{\frac{D_0/2}{MU_1} \cdot WF \cdot 2} = \frac{200 + \frac{200 \times 10 \times 0.2}{20}}{\frac{100}{147} \times 0.8 \times 2} = 202$$

⇒ verify:

dose in first 10 fx: $200 \times 0.8 \times 10 = 1600$

20 fx: $(202 \times \frac{100}{147} \times 0.8) \times 2 \times 20 = 4397$

No questions on TBI this time. No questions about occupational or public dose limits. Lots of dose calcs. No electron calcs that I can remember. A sizable amount of rather obscure information was included in the simple questions. Most of the complex questions were more reasonable but I ran out of time and had to guess on the last few. Don't waste time on the simple questions you don't know!!

2009 Part II Recall:

1. For regular photon Linac, the major contribution of photon dose at maze door:
   A. Leakage through maze wall
   B. Leakage scattered through wall
   C. Patient scattered

2. For ion-chamber used for calibration, what is the limit for chamber leakage:
   A. 10^{-12} B 10^{-14} C10^{-10} D10^{-8}

3. Based on TG-66, the tolerance for the alignment of gantry laser with the image isocenter is: +/-1mm; +/-2mm and so on

4. A question about electron TG-51 calibration. Calculate cross-calibration p.p.l chamber: $Kecl*N_{D,W}$. Given reading M, correction factors, R50, KR50' formula for ppl and dose calibration factor for cylindrical chamber.

5. Physics wedge will:
   A. increase skin dose, increase PDD
   B. reduce skin dose, increase PDD
   C. increase skin dose, decrease PDD
   D.

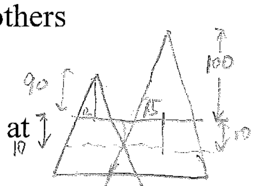
$1.5 = \frac{1.0-0.45}{\log(D_1)-\log(D_2)} = \frac{0.55}{\log(\frac{D_1}{D_2})}$

$\log(\frac{D_1}{D_2}) = \frac{0.55}{1.5} = 0.36667$

6. IMRT film QA, two areas with optical density 1.0 and 0.45; film gradient is 1.5, what is the ratio of doses on these two areas?
   A. 2:1 B 3:1 D. 3.5:1

7. What material has the highest neutron production rate: Tin, Lucite, Lead and others

8. Gap calculation: Field A: SAD treatment, SSD=90, d=10 and field size (FS) at SSD=24cm, Field B SSD=100, FS=15 at SSD, what is skin gap to match dose at depth=10cm? Answers: A 1.9cm B2.1cm C 2cm



9. Conformity index = 2.7 and GTV volume =5.4cm^3, what is the volume of tissue irradiated.

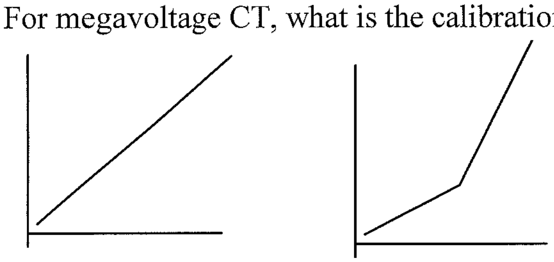
$\frac{12}{90} = \frac{x_1}{10}$

$\frac{7.5}{100} = \frac{x_2}{10}$

$x_1 = \frac{12\times10}{90} + \frac{7.5\times10}{100}$

$= 2.08$

10. For megavoltage CT, what is the calibration curve HU to electron density.



11. Spiral CT, collimator: 4 slices with 1mm thickness, gantry rotation time =1.5s, what is total time to scan 100mm?

4mm

12mm

pitch = $\frac{\text{Table travel speed per rotation}}{\text{Collimator size}}$

$= \frac{x \text{ mm/rotation}}{4\text{mm}}$

$e^{-\mu \cdot 2.8} = 0.5$

$\mu = 0.2475$

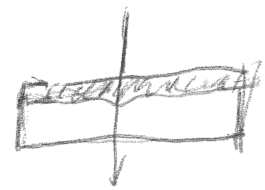
0.19

12. HVL =2.8cm for some material, $\mu^{water} = \cancel{1}.9cm^{-1}$. What is the CT number for the material: A: 1000HU B:2000HU C:100HU D 0

13. Give a CT slice, showing 3cm chest wall, 11cm lung, 1cm tissue to point A, dose to point A is 200cGy and calculated without inhomogeneity correction. What is the real dose to point A? answers include 246cGy, 255cGy

14. What is difference between PDD (%10) and (%dd)x in TG-51:
    A. e- contamination is significant at d=10cm
    B. (%dd) is used to find KQ where (%dd) is used to convert/calculate dose at dmax.

15. where is effective point of measure of p.p.l chamber?
    A. proximal side of cavity
    B. distal side of cavity



16. Wedge calculation: total 60Gy in 30 fx. In first 10fx, 147MU given and then realize missing wedge factor 0.8. To compensate the dose in next 20fx, what is new MU: A. 202MU'

17. Gamma knife: localization error: 1.5mm and some other error 0.5mm, for quadratic total error? (square root of two errors)

18. HDR calibration: Give Sk on some date from vendor, then current measured after two weeks and chamber calibration factor is also given. What is difference between measured and vendor value? (Need to know dose = current * calibration factor * inversed decay correction)

19. Two shielding questions: For 6MV and 18MV, both TVL_1 and TVLe given. Concrete thickness 95cm. To find extra thickness if the room shield is needed if energy change from 6x to 16x. (need to know thickness = TVL_1 + (n-1)*TVLe) .
    The other question is very similar, but given TVL for both 6MV and 16MV, some thickness of thickness of shielding, find difference exposure readings behind the wall. (I can not recall this clearly. But the question is basically to ask you calculate transmission between different energies)

20. For primary wall shielding, Point A is 6m away from isocenter, point B is 12m away from isocenter. The beam is only 30s on the wall for each patient. Dose measured at point A is 0.06mSv/hr. Work load at iso was given. How many patients can be treated that dose at point B will not be greater than 0.02mSv/hr (The same question as No.11 of 2008 exam)
    (Ans: A. 26; B. 30)

21. For electron beam, f slope for gap = 0.0111 was given, SSD=100cm, dm =2cm, what is effective SSD?

22. TG-51, given all parameters, T, P, readings at 150V, 300V, Ppol, Pecl, KQ, Nd,w, and SSD=100cm, PDD(10)=0.753, find dose at dm.

23. A few simple calculation of TG-43, give Sk, dose rate constant, G(r, θ) following IVS, g(r) and F(r, θ) given. Basically you need to convert units (cGy <-> Gy, hr <–> min), then you can calculate dose rate and find total dose and so on.

24. What happen if megatron current is increased?
A. RF power reduce   B. Beam energy increase

25. If bending magnet is not working, what observation you will have:
A. Dose rate reduce   B. field symmetry change   C. beam energy change ……

26. What is the limiting dose that when 30% of kidney get irradiation and will have irresisipible damage.
C. 2000cGy   D. 3500cGy .. I don't remember if there is 5000cGy in answer

27. When using regular fractionation (1.8Gy/fx, some number of fx) , what is the TD5/5 of xxxx (a word that I don't recognize, probably some side effect) for parotid. (answers include: 10Gy, 30Gy, 50Gy ….)

28. BED calculation: 54Gy /30fx. Alfa/belta =10Gy, calculate dose per fx if want to deliver in 20fx.

$BED = nd\left(1+\frac{d}{\alpha/\beta}\right) = 54\times\left(1+\frac{1.8}{10}\right) = 20\cdot d\left(1+\frac{d}{10}\right)$

29. Brachy source shield by 2cm lead (HVL = 5.5mm), container diameter 30cm, T=3.26Rm2/hr/mCi (I don't remember the number and unit). What is the max activity can be in the container to make the exposure less than 50mR/hr at the surface.

$2d^2+20d-63.72=0$

$d = \frac{-20\pm\sqrt{20^2+2\times4\times63.72}}{4}$

$3.26\times X\times e^{-(\frac{.693}{5.5}\times20)}\times\left(\frac{1}{15}\right)^2 = 50mR \Rightarrow 0.05R \Rightarrow 43.02$

$d = 2.54$

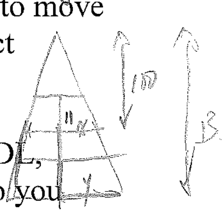
30. In cone beam CT, if some detectors only works intermittent (I don't recognize that word) , what artifact the image will have: A. band   B. ring C. streaking D.

31. calculate leakage workload: # of patient 20 per day, 5 days per week, dose per patent = xxx Gy. 65% are conventional tx, 35% are IMRT, and C_{IMRT} =4, average treatment PDD = 65%, what is the workload?

$\left(\frac{200}{0.65}\times0.65+200\times4\times0.35\right)\times100 = 480\ Gy\ ?$

$\left(200+\frac{200}{0.65}(4\times0.35)\right)\times100 = 631\ Gy$

32. film cut question, SAD =100cm, separation =22cm, film at 135cm. then want to move to SSD=100cm, what is film distance? Answers: 144cm (I did not get the exact answer, but close to one of this number 146cm?)



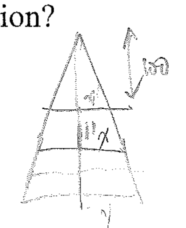
33. e- treatment for a superficial lesion with diameter of 4.5cm, 200cGy to 80% IDL, what is MU? Give cone factor of 6x6 (0.98), 10x10 (1.0) and 15x15 (1.02). So you need to decide which cone to use.

$\frac{x}{100} = \frac{y}{135}$ $\frac{y}{x} = \frac{135}{100}$

34. What kind of heterogeneity correction is used in collapsed cone calculation?

$\frac{x}{100+11} = \frac{y}{?}$

$? = \frac{(100+11)y}{x}$ $\frac{135}{100}$



$\frac{x'}{x} = \frac{11}{100+11}$

35. IMRT QA point verification should be at: A. low dose high gradient B. High dose low gradient and so on.

36. How many ___% of brachy seeds need to be surveyed and at what percentage different___ that you need to report to vendor?

37.

35. IMRT QA point verification should be at: A. low dose high gradient B. High dose low gradient and so on.

36. How many ___% of brachy seeds need to be surveyed and at what percentage different___ that you need to report to vendor?

37. Which is the most sensitive device to detect ^{125}I:
A: G-M counter B. Thin-window G-M counter

38. A 9-inch polyethylene sphere surrounding BF3 with cadmium rod is best to measure:
A. thermal neutron B. fast neutron