

Helpful Equations to Study

Checklist for Equations & Numbers & Relations

1. Ci:	3.7×10^{10} dps (Bq)
2. mCi:	3.7×10^7 dps (Bq)
3. Exposure:	Roentgen 0.58×10^{-4} C/kg
4. Absorbed Dose:	Rad, Gray
5. 1 Gray =:	100 Rad $1 \text{ Rad} = 100 \text{ erg/gram}$
6. Dose Equivalent:	Rem, Sv $(\text{Rad} \times \text{QF} + \text{Geom.})$
7. 1 Sv =:	100 Rem
8. Alpha Decay:	A-4, Z-2
9. B-Decay:	A, Z+1
10. B+ Decay:	A, Z-1
11. Ebeta:	Avg = $1/3 E_{\text{max}}$
12. Activity Equation:	$A_0 = A e^{-\lambda t}$
14. Decay constant:	$\lambda = 0.693 / T_{1/2}$
15. <u>Isotope Half Life</u>	<u>Half Life</u>
Pd - 103:	17 days
I-125	60 days
Ir-192	74 days
Co-60	5.3 yrs
Cs-137	30 yrs
Ra-226	1600 yrs
16. <u>Isotope Energy</u>	<u>Energy</u>
Pd-103	21 keV
I-125	27 keV
Ir-192	380 keV
Co-60	1.25 MeV avg
Cs-137	662 keV $\approx 1462 \text{ meV}$
Ra-226	883 keV $\approx 883 \text{ meV}$
Sr-90/Y-90	2.2 MeV Beta
17. Secular Equilibrium $P^{226} - P^{222}$	$T_p \gg \gg \gg T_d$ up $\ll \ll \ll \ll$ ud Sr^{90}/Y^{90}
18. Transient Equilibrium $m^{99} - T^{99}$	$T_p > T_d$ up $<$ ud

w/kon

19. PE	Z ³ , 50 keV
20. CS	Inde, 30 keV – 30 MeV
21. PP	Z ² , >1.022 meV
22. CS photon at 90 degrees	511 keV <i>511 meV</i>
23. CS photon at 180 degrees	250 keV <i>250 meV (255 keV)</i>
24. Attenuation equation	$I - I_0 e^{-\mu t}$
25. Half Value Layer	$U = 0.693 / HVL$
26. Graph	Graph
Act vs time	Linear
Act vs time	Semi – Log
I vs thickness	Linear
I vs thickness	Semi-Log
27. X-ray production (diag) vs mAs	Proportional to mAs
28. X-ray production (diag) vs kVp	Proportional to kVp ²
29. Thoraceus filter order:	Tin-Copper-Aluminum *
30. Superficial E range	50-150 kVp
31. Orthovoltage Range	150-500 kVp
32. BJR 17 requires:	HVL & SSD <i>NOT filtration</i>
33. Co-60 Unit dose rate:	240 cGy/min
34. Co-60 Leakage:	10 mR/hr max, 2 mR/hr avg <i>(off)</i>
35. Co-60 source size	1.5-2.0 cm <i>P₁ = 15mm</i>
36. Linac focal spot size:	0.5-3mm <i>P₂ = 8-10mm</i>
37. Transmission Thru:	Percentage
Jaw	1%
MLC	2% <i>1-2</i>
Intraleaf MLC	4% <i>3-4</i>
Cerrobend	3.5%-5% <i>hvl = 1.5cm 7.5cm = 5 HVLs</i>
38. Equivalent Square Question:	4A/P <i>q.l.w / L.T.W</i>
39. PDD	Dd/Ddmax at SSD
40. MF	See notes $PDD = \frac{(SSD^2 + D_{max})}{(SSD^2 + D)}$ <i>(SSD + D)</i>
41. Energy and dmax	Depth
250 keV	Surface
1.25 MeV <i>like Co-60</i>	0.5
4 MV X	1.0
6 MV X	1.5
10 MV X	2.5 <i>15x = 2.8</i>
18 MV X	3.5

ON .1% of dose in air @ 100cm 1 meter

(SSD + D)

Dmax

6 MeV electron	1.2
9 MeV electron	2.0
12 MeV electron	2.5
42. TAR	Dd/Dfs at SAD
43. BSF	Dmax / Dfs at SAD
44. TMR	Dd / Ddmax at SAD
45. TPR	Dd / Dref at SAD
	(dref = 5cm for 6X; 7cm for 18X) $> \text{max } D_{\text{max}}$
46. BSF largest for:	0.7 mm Cu HVL Ortho
47. WF	Output w wedge / Output w/o wedge
48. 1.0 cm Pb =	1.2 cm cerrobend
49. Wedge angle defined:	50% angle isodose with normal $D = 10$
50. Hinge Angle formula	WA = 90 - Hinge Angle / 2 WA = (180 - Hinge Angle) / 2
51. Penumbra Equation:	$P = s(SSD + d - SCD) / SCD$
52. Penumbra Co-60	15 mm $f.s. = 1.5 \cdot 20 \text{ cm}$
53. Penumbra Accelerator	8 mm $f.s. = 5 \cdot 3 \text{ mm}$
54. Contralateral Breast	200 rad
55. Pacemakers Limit	200 rad
56. TBI Rx dose	1000-1200 cGy
57. TBI dose rate	5-10 cGy/min $w \& @ 200 \text{ cGy/hr} = 3.3 \mu \text{m in}$
58. IORT single fx dose	100-2000 cGy
59. Stereotactic Gamma Knife accuracy	0.3 mm
60. Stereotactic Linac accuracy	1.0 mm
61. Electron Max Range	E/2
62. Electron d80	E/3
63. MU equation SSD	See notes
64. MU equation SAD	See notes
65. Dose to other point SSD	See notes $\text{Calc pt dose} \times \frac{PDD_2}{PDD_1}$
66. Dose to other point SAD	See notes $\text{Calc pt dose} \times \left(\frac{TMR_2}{TMR_1} \right) \left(\frac{SSD_1}{SSD_2} \right)^2$ - do for both fields
67. Gaps	Gap = FS/2 * (d/SAD)
68. Coll Rotation, Table	Tan angle = 0.5 * L / SSD $\text{Spine} = \text{Coll}$
69. Electron MU	See notes $\text{Brain} = \text{coll}$
70. Brachy Exposure	$X = A * \Gamma / d^2$
71. Exposure Rate Constant Ra-226	8.25 R-cm ² / mg-hr
72. Ra-226 to Cs-137 conversion	10 mg Ra = 25 mCi Cs-137
73. Cumulative Dose Brachy	Dose = 1.44 T ^{1/2} /2 * initial dose rate
74. CT Number Water	0
75. CT Number Bone	1000
76. CT Fat	-100
77. CT Lung	-400
78. CT Air	-1000

Review

Review

79. Best DRRs	Thinnest slice, smallest skip
80. CT accuracy	1 mm
81. MRI accuracy	2 mm
82. Air Kerma units:	$\mu\text{Gy}\cdot\text{m}^2/\text{hr}$ $7.227 \frac{\mu}{\text{mg}}$
83. Pt A Dose gyn LDR	50 – 60 cGy/hr
84. Pt B Dose	Pt A dose / 3
85. I-131 Therapy Dose	> 30 mCi
86. I-131 radiation and $T_{1/2}$	Beta decay / 8.05 day
87. Prostate seed I-125 dose rate:	5 – 10 cGy / hr
88. Prostate seed Pd-103 dose rate:	20-30 cGy / hr
89. LDR dose rate	40 -200 rad / hr
90. MDR dose rate	200 -1200 rad / hr
91. HDR dose rate	>1200 rad / hr
92. HDR unit source	10 Ci Ir-192
93. HDR source positioning accuracy	1 mm
94. Vascular brachy Rx dose	15-20 Gy $1500 - 2000 \text{ cGy}$
95. Vascular brachy Rx pt	2 mm
96. <u>PDD</u>	<u>Drawings</u>
6 MV X	
18 MV X	
6 E	
18 E	
250 MeV Proton	
Orthovoltage 250 k Vp	
Co-60	
97. <u>Isodose Curves</u>	<u>Drawings</u>
6E	
18E	
6X open	
6X 45 degree wedge	
6X thru bone	
6X thru lung	
6X anterior partial arc (330 – 30)	
6X bilateral prostate arc	
6X full 360 arc	
Brachy tandem and ovoid	
Brachy Prostate seed 70m^3	
98. LD 50.30 (old)	450 rad
99. LD 50/60 (new)	350 rad
100. dVh Y axis	Volume

Ir 192
Cs 137
Ra



101. dVh X axis	Dose
102. <u>Organ</u>	<u>Tolerance (cGy)</u>
Ovary	300
Testis	200
Cataracts	500
Kidney	2000
Liver	2500
Spinal Cord	4500
Heart	4500
103. <u>Radiation Exposure Limits</u>	<u>Limit</u>
Whole Body	5 Rem <i>50 mSv</i>
Organ	50 Rem <i>500 mSv</i>
Fetus	500 mRem <i>5 mSv</i>
Public	100 mRem <i>1 mSv</i>
Public	<2 mR/hr
104. Film Badge if:	>10% of limit or high rad area
105. Thyroid ablation release	< 5 mR/hr or 30 mCi
106. SS Inventory	3 months
107. SS Wipe Test	6 months
108. SS Wipe Test Results	< 0.005 uCi
109. Misadministration	>20%, patient, site, isotope, remove, leaking, call NRC
110. Recordable Event	>10%, no script, internal report
111. <u>Shielding Parameters</u>	<u>Parameter</u>
P	Permissible level
W	Workload
U	Use Factor
T	Occupancy Factor <i>1</i>
112. Neutrons produced by linacs	>10 MV X
114. Neutrons shielding problems	> 15 MV S
115. Monthly linac output	2%
116. Monthly flatness	3% of 80% field at d10 <i>dmax e-</i>
117. Monthly symmetry	2% of 80% field at d10 <i>dmax e-</i>
118. Co-60 timer error	0.02 minute <i>0.10 min for linac - end effect</i>
119. Gantry / collimator	1 degree
120. Mechanical	2 mm
121. Rad / Light	2 mm

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

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

122. Equipment calibratn equipment	Prior to use, repair, 2 yrs by ADCL
123. Temp-Pressure correction	$(273 + T)/295 * 760/P$
124. Calibration Protocols (new)	TG-51
125. Calibration Protocols (old)	TG-21
126, QA Protocol	TG-40 at 40 you need

QA

Tg43
Brachi