1. Dosimetry Calculations

a) Monitor Units for Target-Axis-Distance (TAD) Setup:

$$MU = \frac{TD \cdot Wt}{K \cdot TMR(r_{eff}, d) \cdot TSF(r) \cdot TF \cdot WF \cdot (SCD/SPD)^2 \cdot OAR(x, y, d)}$$

(a) Where:

TD = Dose to point

Wt = Beam weighting

K = Machine output (typically 1cGy/MU)

TMR(r,d) = TMR which depends on the energy used, the effective field size and the axis depth.

TSF(fs) or C_{fs} = Total Scatter Factor which depends on the energy used and the field size.

TF = Tray Factor which depends on the energy used and the tray thickness.

WF = Wedge factor which depends on the energy used and the wedge angle.

SCD = Source Calibration Distance

SPD = Source Point Distance

OAR = Off Axis Ratio

b) Monitor Units for Target-Skin-Distance (TSD) setup:

$$MU = \frac{TD \cdot Wt \cdot 100}{K \cdot P(d, r, f) \cdot TSF(r) \cdot TF \cdot WF \cdot \left[SCD/(f + d_{\max})\right]^2 \cdot OAR(x, y, d)}$$

(a) Where:

TD = Dose to point

Wt = Beam weighting

K = Machine output (typically 1cGy/MU)

P(d,r,f) = Percent Depth Dose which depends on the energy used, the equivalent field size, the SSD and the axis depth.

TSF(r) or C_{fs} = Total Scatter Factor which depends on the energy used and the field size.

TF = Tray Factor which depends on the energy used and the tray thickness.

WF = Wedge factor which depends on the energy used and the wedge angle.

SCD = Source Calibration Distance

f = SSD of treatment

OAR = Off Axis Ratio

Example 1:

6 MV, 180 cGy per treatment with AP/PA fields
AP SSD = 90 cm, d=10
PA SSD = 88 cm, d = 12
Field Size = 12 x 12

Use the SAD (or Isocentric) method with TMR

$$MU = \frac{TD \cdot Wt}{K \cdot TMR(r_{eff}, d) \cdot TSF(r) \cdot TF \cdot WF \cdot (SCD/SPD)^2 \cdot OAR(x, y, d)}$$

TD = 90 cGy (AP & PA)
K = 1.0 cGy/MU (assume if not given)
TMR(12 x 12, d=10) = 0.810 (AP value)
TMR(12x12, d=12) = 0.756 (PA value)
TSF(12x12) = 1.015
TF = 1.0
WF = 1.0
SCD = 101.5 (SSD + Dmax)
SPD = 100.0 (SSD + depth)
OAR = 1.0

So,

$$MU = \frac{90 \text{ cGy}}{(1.0 \text{ cGy/MU}) \times (0.810) \times (1.015) \times (1.0) \times (1.0) \times (101.5/100)^2 \times (1.0)} \quad \text{AP Beam}$$

$$MU = \frac{90 \text{ cGy}}{0.8468}$$

MU = 106.3 MU AP Beam

Now, repeat for the PA. Noting that the TMR value is different (different depth).

$$MU = \frac{90 \text{ cGy}}{(1.0 \text{ cGy/MU}) \times (0.756) \times (1.015) \times (1.0) \times (1.0) \times (101.5/100)^2 \times (1.0)} \quad \text{PA Beam}$$

$$MU = \frac{90 \text{ cGy}}{0.7903}$$

MU = 113.9 MU PA Beam

Notes:

1. Either AP or PA beam could have a wedge or block tray
2. If blocks are used, you need to compute the equivalent square first to look up the TMR and C_{fs} (or TSF as it is called here)

Example 2:

6 MV, direct PA spine field treatment.
250 cGy, 100 SSD, depth = 6 cm
Field Size = 8 x 24
Open fields

Use the SSD (or Percent Depth Dose) method:

$$MU = \frac{TD \cdot Wt \cdot 100}{K \cdot P(d, r, f) \cdot TSF(r) \cdot TF \cdot WF \cdot \left[SCD/(f + d_{\max})\right]^2 \cdot OAR(x, y, d)}$$

TD = 250 cGy
K = 1.0 cGy/MU
Eq. Sq. = 4(8)(24)/(8+8+24+24) = 12.0 cm
P(d=6, r=12.0, f=100) = 83.9
TSF(12x12) = 1.015
TF = 1.0
WF = 1.0
SCD = 101.5
f+Dmax = 100 + 1.5 = 101.5
OAR = 1.0

$$MU = \frac{(250\ cGy) \times (100)}{(1.0\ cGy/MU) \times (1.015) \times (83.9)\ X\ (1.0) \times (1.0) \times (101.5/101.5)^2 \times (1.0)}$$

$$MU = \frac{25000}{85.16}$$

MU = 293.6 MU

Now – let's do the same problem using the TMR method:

$$MU = \frac{TD \cdot Wt}{K \cdot TMR(r_{eff}, d) \cdot TSF(r) \cdot TF \cdot WF \cdot (SCD/SPD)^2 \cdot OAR(x, y, d)}$$

TD = 250 cGy
K = 1.0 cGy/MU (assume if not given)
Eq. Sq. = 12.0 cm
TMR(12 x 12, d=6) = 0.919
TSF(12x12) = 1.015
TF = 1.0
WF = 1.0
SCD = 101.5 (SSD + Dmax)
SPD = 106.0 (SSD + depth)
OAR = 1.0

$$MU = \frac{(250\ cGy)}{(1.0\ cGy/MU) \times (0.919) \times (1.015) \times (1.0) \times (1.0) \times (101.5/106)^2 \times (1.0)}$$

$$MU = \frac{(250\ cGy)}{(1.0\ cGy/MU) \times (0.919) \times (1.015) \times (1.0) \times (1.0) \times (0.9169) \times (1.0)}$$

$$MU = \frac{250}{.8553}$$

MU = 292.3 MU Same answer! (well, within 0.5%)

Problems: All problems are for the 6 MV beam (see Appendix 5). Calibrated at 100 SSD + 1.5 cm (101.5 cm) and has a calibrated output (K) of 1.0 cGy/MU at that point. Tray factor = 0.97.
Use the Table in the book or 4A/P to determine equivalent squares.

1. Rt/Lt Lateral neck fields.

180 cGy with even weighting (90 per side).
12 X 10 field Size – open fields
Rt & Lt SSD = 93, depth = 7 cm **Ans: 101 MU each beam**

2. Four Field Pelvis

180 cGy per treatment. Weighted 3:2 from AP/PA: Rt/Lt laterals
12 x 12 fields all around, open fields
AP SSD = 85 cm, depth = 15 cm
PA SSD = 90 cm, depth = 10 cm
Rt & Lt Lateral SSD = 80, depth = 20 cm
Rt & Lt Lateral Fields have 15 degree wedges (Wedge Factor = 0.708)

Weighting 3:2 means that the AP/PA beams will get 3 parts of the dose and the lats will get 2 parts of the dose.
To do uneven weighting (i.e. – 3:2), divide the total dose by the sum of the weights – 180/(3+2) = 36 cGy.
So, the AP & PA beams get 3 x 36cGy = 108 cGy (54cGy each)
And the Laterals will get 2 x 36cGy = 72 cGy (36 cGy each)

Ans: AP – 58, PA – 65, RT/LT – 89 MU

3. Extended Distance L-S spine

250 cGy per treatment.
Single PA field
Field Size = 10 x 25 on the digital display (i.e. at 100 cm)
SSD = 115 cm
Depth = 6 cm
Hint: need to figure out the field size at 115 cm to look up the PDD & if using PDD need to apply Mayneord f-factor for 115 SSD.
If you use the TMR method, you need to know the field size at 115 SSD + 6 cm=121 cm.

Ans: 379 MU

4. Whole brain treatment

250 cGy per day delivered through Rt & Lt Lateral field
Field Size: 24 X 17, blocked to an Eq Sq of 17 cm (don't forget tray factor)
Rt Lateral SSD = 90 cm, depth = 10 cm
Lt Lateral SSD = 89 cm depth = 11 cm **Ans: AP-146, PA-152 MU**

5. Single C-spine treatment

200 cGy per treatment
SSD = 100 cm
Depth = 5 cm
Field Size = 8 x 15, open field
Hint: use PDD method and check with the TMR method

Ans: 232 MU

6. 3-Field Lung Boost

180 cGy per day, weighted 3:2:1 for AP:PA:RtLat.
Treatment to isocenter
Field size = 6 x 8
All fields have blocks.
AP field has a 15 degree wedge
Rt Lat Field has a 45 degree wedge

AP SSD = 92
PA SSD = 85
Rt Lat SSD = 95

Ans: AP-79, PA-105, Rt-71 MU