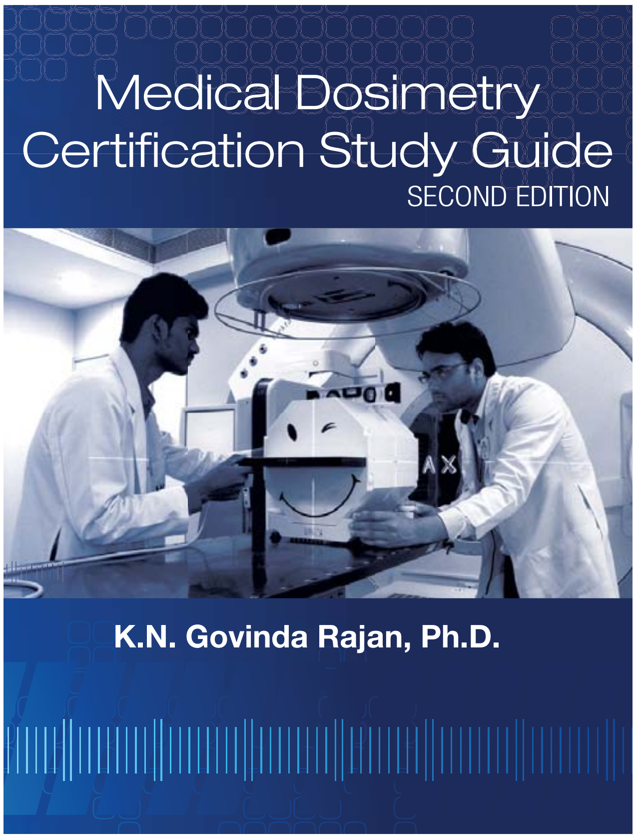
mpp MEDICAL PHYSICS PUBLISHING



Here is a sample chapter from this book.

Here are some sample questions and answers from

Chapter 1: Radiation Physics

I. Radiation Physics

A. Radioactivity

Circle the right answer (Yes or No):

1. (Yes / No) An alpha particle is identical to a helium nucleus with a mass number of 4 and an electrostatic charge of +2.
2. (Yes / No) Alpha particles are usually emitted by low-Z radioactive elements during radioactive decay.
3. (Yes / No) Alpha emission changes the identity of the radionuclide.
4. (Yes / No) ^{226}Ra is an alpha emitter.
5. (Yes / No) ^{60}Co is an alpha emitter.
6. (Yes / No) A beta particle is an electron emitted by the atomic nucleus during radioactive decay.
7. (Yes / No) ^{60}Co is a beta emitter.
8. (Yes / No) ^{192}Ir is a beta emitter.
9. (Yes / No) Emission of beta changes the identity of the radionuclide.
10. (Yes / No) A positron is a positively charged particle but identical to an electron in all other respects.
11. (Yes / No) Beta decay is usually associated with proton rich radionuclides.
12. (Yes / No) Positron decay is usually associated with neutron rich radionuclides.
13. (Yes / No) Emission of gamma radiation does not change the identity of the radionuclide.
14. (Yes / No) Gamma usually follows beta particle emission in radioactive decay.
15. (Yes / No) There are no pure beta emitters.
16. (Yes / No) There are no pure gamma emitters.
17. (Yes / No) Electron capture usually occurs in high-Z radioactive elements.
18. (Yes / No) Electron capture and beta emission are competing modes of decay.
19. (Yes / No) Beta particles emitted in radioactive decay are monoenergetic.

20. (Yes / No) A neutrino is a particle of negligible mass and zero charge postulated to account for the nonconservation of energy during beta decay.

21. (Yes / No) A neutrino is easy to detect.

22. (Yes / No) Mass is conserved in radioactive decay.

Match the following:

23. Match the radionuclide to the nature of its emitter.

a. ^{222}Rn	_____	i.	beta emitter
b. ^{32}P	_____	ii.	alpha emitter
c. ^{59}Ni	_____	iii.	pure beta emitter
d. ^{90}Sr	_____	iv.	electron capture radionuclide
e. ^{125}I	_____	v.	positron emitter

24. Match the gamma emissions to radionuclides.

a. 1.17 and 1.33 MeV gammas	_____	i.	^{222}Rn
b. 0.662 MeV gamma	_____	ii.	^{60}Co
c. Several gammas of mean energy around 400 keV	_____	iii.	^{137}Cs
d. Several gammas of mean energy around 0.8 MeV	_____	iv.	^{125}I
e. Mean energy 28 keV	_____	v.	^{192}Ir

25. Match the half life to its radionuclide.

a. 5.26 years	_____	i.	^{226}Ra
b. 30 years	_____	ii.	^{60}Co
c. 74 days	_____	iii.	^{137}Cs
d. 1626 years	_____	iv.	^{125}I
e. 59.6 days	_____	v.	^{192}Ir

Choose the right answer:

26. The mean life of ^{192}Ir source is given by _____ days.
 a. 106.5
 b. 90
 c. 120
 d. 350

27. After two half lives, the initial activity of a given radioisotope would have reduced to _____.
 a. one half
 b. no reduction
 c. one third
 d. one fourth

28. The mean life of a radioactive source is given by _____.
 a. 1.5 $T_{1/2}$
 b. 2.4 $T_{1/2}$
 c. 1.44 $T_{1/2}$
 d. 2 $T_{1/2}$

I. Radiation Physics ANSWERS

A. Radioactivity

1. Yes
2. No Alpha emission is found only in high-Z, highly unstable large nuclei that exist in natural radioactive series.
3. Yes Because Z change results in a different radionuclide.
4. Yes
5. No It is a beta emitter. The emission results in an excited state of ^{60}Ni which goes to ground state by gamma emissions. The gamma energies 1.17 and 1.33 MeV usually attributed to the ^{60}Co source thus actually are emitted from ^{60}Ni.
6. Yes
7. Yes
8. Yes
9. Yes
10. Yes They are practically identical.
11. No In a beta decay, a neutron becomes a proton, so there is a tendency to increase proton number. Nuclides decaying by beta decay are neutron rich (having too many neutrons compared to the number of protons).
12. No Positron decay transforms a proton into a neutron, so they are proton-rich (neutron-deficient) radionuclides.
13. Yes Gamma emissions take the nuclides only from excited states to ground state.
14. Yes Because beta emissions often leave daughter nuclides in excited states.
15. No There are many pure beta emitters (e.g., ^{32}P and ^{90}Sr nuclides). In these decays, beta emissions simply leave the daughter nuclides in their ground state.
16. No In some sense, there are pure gamma emitters. When the excited state of the daughter nuclide is having a long half life, the nuclides behave as pure gamma emitters (e.g., ^{99m}Tc).
17. Yes This is because the K-shell is very close to the nucleus as a result of the strong electrostatic attraction of the nucleus.
18. No Electron capture and positron emission are competing modes of decay (and they lead to the same daughter nuclide by converting a proton into a neutron).

19.	No	Beta particles emitted have a spectrum. This is because beta decay is accompanied by the emission of an antineutrino which can have different energies.
20.	Yes	Precisely.
21.	No	Detecting a neutrino is an Herculean task, because particles are usually detected by their electrostatic, electromagnetic, or nuclear interactions and neutrinos are incapable of these interactions.
22.	Yes	Of course.

23. a. ii. b. iii. c. iv. d. i. e. iv.

24. a. ii. b. iii. c. v. d. i. e. iv.

25. a. ii. b. iii. c. vi. d. i. e. iv.

26. a

27. d

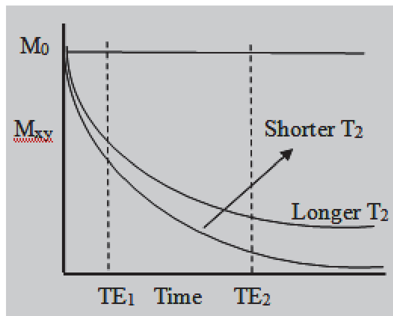
28. c

Here are some sample questions and answers from

Chapter 2: Localization

96. When a patient is placed on a 1 T MRI scanner, the scanner applies a magnetic field along his long axis. Which of the following consequences occur in this situation?
    a. All the protons in the body are aligned parallel to the magnetic field.
    b. The protons align parallel or anti-parallel to the scanner magnetic field.
    c. The parallel alignment is a bit more favored (about 6 parts per million for a 1 T unit).
    d. This creates a minute net magnetization along the scanner field direction.
    e. This net magnetization can be easily measured.

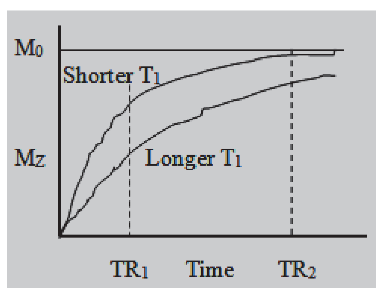
97. Which of the statements deduced from the following figure are true?



Dephasing signal decay

    a. Different tissues exhibit different T_2 values.
    b. The contrast depends on the timing of measuring the MR signals.
    c. At TE_2 the contrast is less compared to contrast measured at TE_1.
    d. The dephasing signal M_{xy} becomes negligible after a few time constants.
    e. All of the above are true.

98. Which of the statements deduced from the following figure are true?



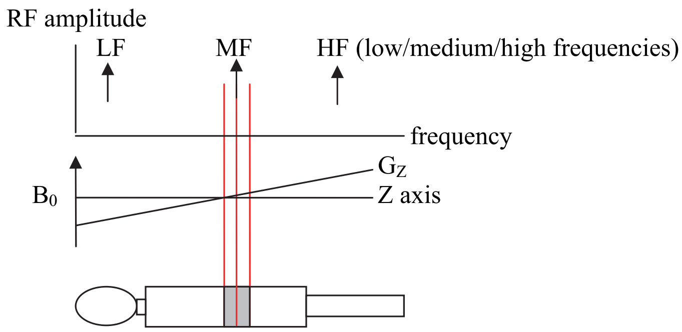
Recovery of MZ signal

    a. T_1 values are characteristic of the tissues.
    b. The contrast depends on the timing of measuring the MR signals.
    c. At TR_2, the contrast is less compared to contrast measured at TR_1.
    d. By proper choice of TR, the image contrast can be manipulated.
    e. For large TR, the signal strength is high but contrast is low.
    f. All of the above are true.

99. From the above two figures and the conditions on TR (repetition time) and TE (echo time) match the type of image to the values of TR and TE.

Image Type	*TR / TE*	
a. T_1 weighted	_____	i. Long/Long
b. T_2 weighted	_____	ii. Long/Short
c. Proton density (PD) weighted	_____	iii. Short/Short

100. How slice selection is made in an MRI (use the figure given below).



Gradient field G_Z varies effective field and, hence, the Larmor frequency, along Z _____.

a. by applying a homogeneous magnetic field
b. by applying a gradient field along the longitudinal axis
c. by applying both the fields simultaneously
d. by applying both fields and sending an excitation pulse simultaneously with the application of gradient field, the RF pulse frequency matching the slice (Larmor frequency) chosen
e. all the above

101. From the figure shown above, one can surmise that slices can be obtained in any arbitrary orientation with respect to the patient axis or the scanner longitudinal axis by _____.

a. changing the direction of the field B_0
b. changing the direction (orientation) of the gradient field
c. changing the orientation of both the fields
d. introducing a third gradient field in the transverse direction

102. From the figure given in problem 100 above, one can guess that slice thickness can be varied by _____.

a. varying the field gradient
b. varying the field B_0
c. varying the RF pulse bandwidth
d. varying the RF pulse frequency
e. all the above methods

103. How is the slice selection made in MRI imaging?

a. An RF pulse is directed at the section of interest in the patient.
b. The imaging slice location is moved to the center of the magnet bore.
c. A magnetic field gradient is temporarily applied along the patient axis.
d. The gradients are applied along X, Y, and Z directions.
e. Slice selection is made by all the above methods.

104. One can uniquely identify each pixel in the slice chosen by the Z gradient field and the RF pulse frequency by _____.

a. applying a phase gradient along a perpendicular direction, say along the X direction
b. applying a frequency gradient along the same direction
c. applying a phase gradient along X followed by a frequency gradient along the Y direction
d. there is no way to identify the signal from each pixel element
e. method b or c

96. b, c, d The magnetization is difficult to measure since this field is very minute compared to the scanner field. However, it becomes measurable if we flip this magnetization away from the direction of the scanner magnetic field, the main functioning principle of MRI.

97. a, b, d The contrast at TE_2 is larger compared to contrast at TE_1, as is clear from the figure.

98. f

99. a. iii. b. i. c. ii.

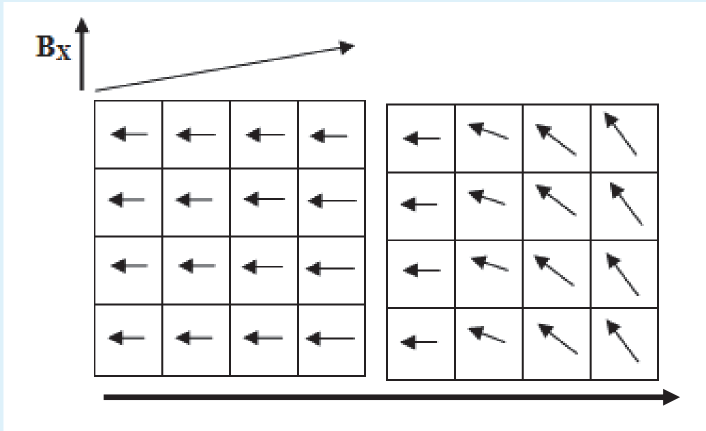
100. d When the field is homogeneous, all the protons are having the same Larmor frequency. The gradient G_Z changes the effective field along Z, and hence the frequencies become a function of Z. Now the slice in question fixes the effective field and the Larmor frequency of the slice, and hence the RF pulse frequency and width that need to be applied for excitation of this slice. See the figure given in the problem.

101. b

102. a, c It is easy to see that reducing pulse width reduces slice thickness. If you double the field gradient, the frequency range also doubles. So for the same pulse width, the slice becomes half. For example, if the gradient is 5 mT/m, a 10 mm slice will have a frequency range of 42, and 58 MHz/T × 5 mT/m = 2. 13 kHz. A pulse of this width can excite all protons in this slice. If the gradient is 10 mT/m, the range of pulse frequencies is 4.3 kHz, so the pulse of 2.13 kHz will excite protons in 5 mm slice thickness. Slice thickness is proportional to the bandwidth and inversely proportional to applied field gradient.

103. c An RF pulse applied is not directed at any slice. It excites protons throughout the scanner bore. The field gradient G_S varies the Larmor frequency throughout the length of the patient. The RF will excite the protons in the slice whose frequencies are in resonance with the RF pulse frequencies.

104. c The figure below explains several features of slice selection in MRI imaging. (The figures are adapted from a presentation by Xiaojuan Li, Dept. of Radiology, UCSF, USA.)

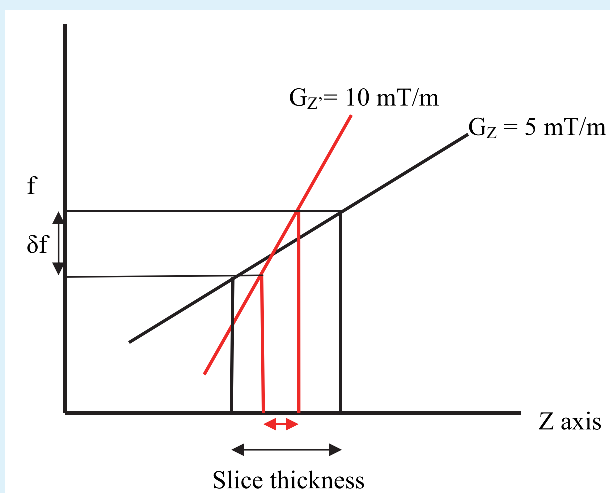


Phase gradient applied for a time ΔT

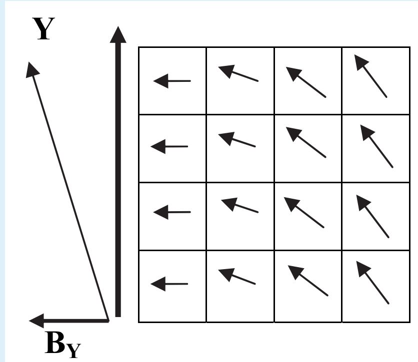
a) The slide has finite thickness (or width, say ΔZ) and so contains a range of frequencies centered on a certain frequency. This pulse can excite all the protons in this slice. for a given field gradient (say G_Z), reducing the pulse width of δf reduces the slice thickness. (ΔZ α δf)

b) It can also be noticed that by keeping δf constant, the slice thickness can be varied by varying the field gradient. For instance, by doubling the field gradient, the slice thickness becomes half (see the figure below).

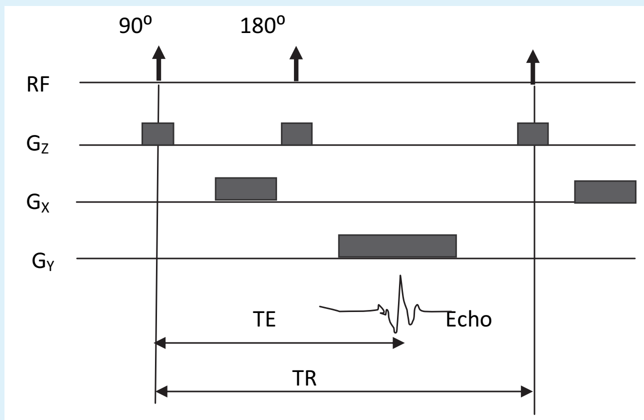
c) If the central frequency is 58 MHz/T, for the G_Z field, δf = 58 MHz/T × 5 mT/m = 2.13 kHz. If the gradient is 10 mT/m, the range of pulse frequencies is 4.3 kHz, so a pulse of 2.13 kHz will excite protons in 5 mm slice thickness. (ΔZ α 1/G_Z).



The data is acquired (signal recorded) while the frequency gradient is ON.

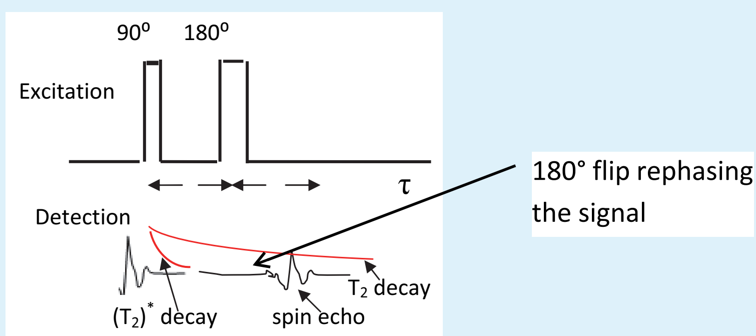


Application of frequency gradient along Y direction

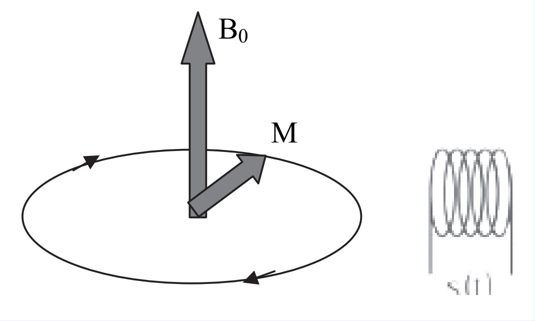


Pulse sequence applied for MRI imaging

A 90° RF pulse produces the flip of the magnetization vector onto the XY plane. The resulting dephasing signal decays fast. 180° pulse applied at TE/2 rephases the dephasing signal and gives us more time for signal encoding before the rephase signal can be measured. (Following figure taken from Yu Cao and Lili Chan presentation on MRI, Fox Chase Cancer Center, USA.)



Phase gradient and frequency gradients applied and the data acquired during frequency decoding duration. The pulse sequence is repeated to read data of each line, before decoding pixel data.



Receiver coil reading the dephasing signal data

If the image is a 256-by-256 matrix, 256 repeated pulse sequences will read 256 rows and the FT will yield the 256-by-256 pixel intensities.

Here are some sample questions and answers from

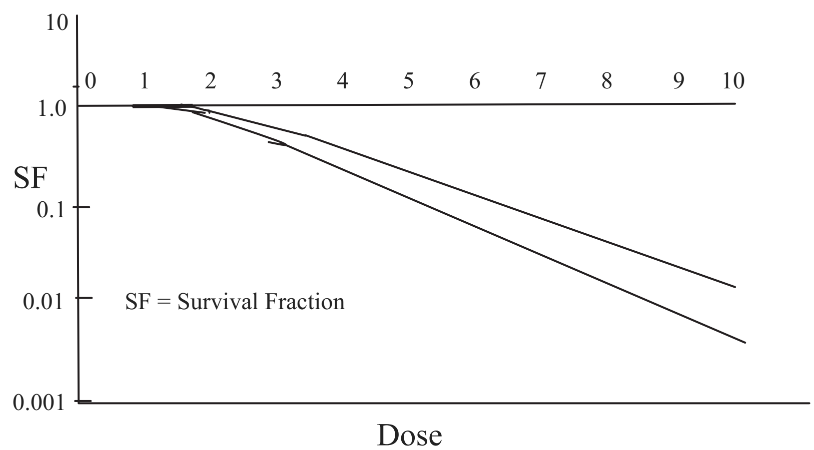
Chapter 3: Treatment Planning, Techniques, and Delivery

78. _____ is the dose required for 10% survival in terms of mean lethal dose D_0.
   a. $1/D_0$
   b. D_0
   c. $2.30 \times D_0$
   d. $2 \times (2.3 \times D_0)$
   e. $(2 D_0)^2$

79. In radiotherapy, the influence of four Rs depends on the total treatment time (T) and time between fractions (t). Match the Rs to their Ts or ts.

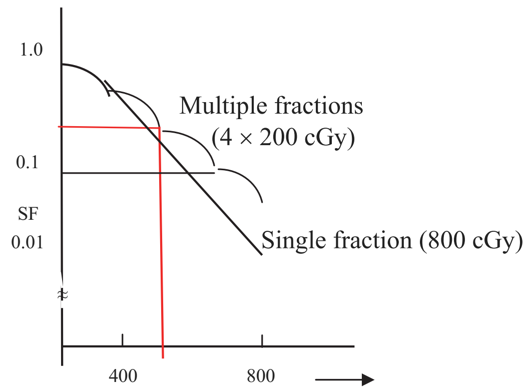
Various Rs	*Influence on T or t*
a. **R**eoxygenation	_____ i. need minimum t for normal tissues
b. **R**edistribution	_____ ii. need to reduce T for tumor
c. **R**epair	_____ iii. need minimum t
d. **R**epopulation (or **R**egeneration)	_____ iv. need minimum T

80. The figure below shows the SF curves for a radiosensitive cell population and a radioresistant cell population.



The dose required to kill 90% of the cells from the radioresistant cell population is _____.
   a. 1 Gy
   b. 7 Gy
   c. 10 Gy
   d. 15 Gy
   e. 20 Gy

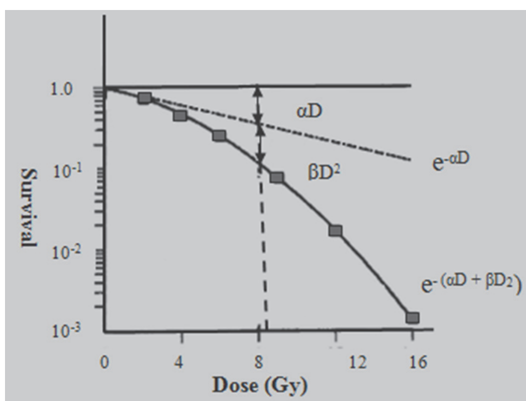
81. What conclusions can be drawn from the survival curve shown in the figure below for x-rays for the normal cells?



Cell survival curve for normal tissue for fractioned radiotherapy

a. It represents the survival curve for fractionated radiotherapy.
b. For a small dose, there is damage repair taking place.
c. Fractionation increases cell survival compared to a single large dose.
d. For the same SF, fractionation requires a larger dose compared to single dose.
e. High-dose treatment is preferable since more cells are damaged.
f. All of the above are true.

82. The cell survival curve for normal cell irradiation with x-rays is shown below.



Survival curve in the Linear Quadratic (L-Q) model

This curve can be represented by a linear quadratic equation: $SF = \exp - (\alpha D + \beta D^2)$. What statements regarding the factors α and β in the equation are true?

a. The α component is responsible for the shoulder representing repairable sublethal damage to the target (DNA).
b. The shape of the curve at higher doses is governed by β which represents irreparable damage.
c. The dose range over which damage repair dominates is determined by α.
d. α/β is about the same for all normal tissues.
e. All of the above are true.

83. Factors affecting tumor growth include _____.

a. cell cycle time
b. growth fraction
c. cell loss fraction
d. tumor oxygenation
e. all of the above

84. Which of the following properties regarding cell cycle growth are true?
   a. Cell cycle time varies widely within a tumor.
   b. Malignant tumor cells cannot be slow cycling.
   c. Tumors of the same type may have different average cycle times.
   d. Benign tumors are generally slow cycling compared to the malignant types.
   e. All of the above are true.

85. The 4 Rs of radiobiology are _____.
   a. repair
   b. reassortment
   c. remodification
   d. reoxygenation
   e. repopulation

86. Which of the following parameters regarding BED are true?
   a. BED stands for biologically equal dose.
   b. BED can be used to differentiate between fractionation regimes.
   c. According the L-Q model, the BED can be shown to be D $[1 + (D/n) / (\alpha/\beta)]$.
   d. BED is the same for late-responding and early-responding tissues.
   e. All of the above are true.

87. A standard treatment scheme is 2 Gy/fraction, 30 fractions. If the dose per fraction has to be increased to 3 Gy, _____ fractions must be delivered for the same biological effect. The tissue is late-responding tissue. (Assume $\alpha/\beta = 3$.)
   a. 30
   b. 24.2
   c. 16.7
   d. 15
   e. 10

88. In the above problem, _____ will be the number of fractions for the new regime if the tissues are early-responding tissues. (Assume $\alpha/\beta = 10$.)
   a. 26
   b. 18.4
   c. 15
   d. 12.8
   e. 4

G. Treatment Techniques and Treatment Delivery

Choose the right answer(s) (more than one may be correct):

1. _____ are the IMRT plan objectives.
   a. Minimum dose to PTV
   b. Maximum dose to PTV
   c. Maximum dose to OAR
   d. Dose-volume constraints for OAR
   e. None of the above

78. d Survival fraction = 0.1 or 10%, so the percentage of cells killed is 90%.

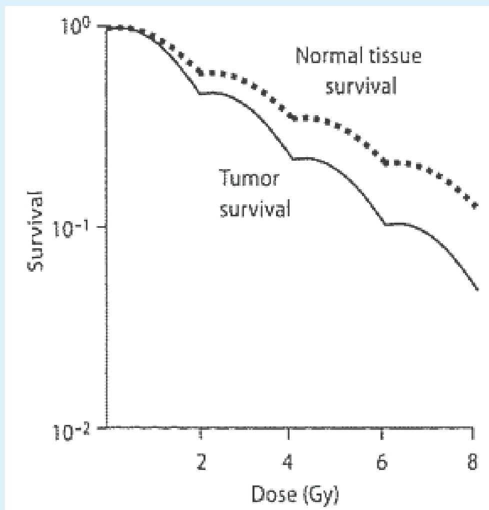
79. c

80. a. iv. b. iii. c. i. d. ii.
All of these requirements cannot be satisfied at the same time. The parameters must be optimized depending on the situation.

81. b SF = 0.1. This corresponds to 0.9 fraction (i.e., 90%) cell killing.

82. a, b, c, d
See the black horizontal line in the figure. It shows that for the same SF, you need to give more dose if you fractionate. It is OK since the cells are being repaired in the interval. See the red vertical line in the figure. For the same dose, fractionation leads to higher cell survival. i.e., fractionated doses do less damage to normal tissues compared to a single large dose. This is important for reducing normal tissue complications.

The following figure illustrates the effect of fractionation on both the tumor and the normal tissue. One can see radiation effects more damage to the tumor compared to the normal tissues that also get irradiated in the treatment plan.



83. a, b, c

84. e

85. a, c, d Some tumor cells are slow cycling.

86. a, b, d, e

87. b, c

88. c Two regimes are biologically equivalent if they lead to the same SF. The BED is derived from the L-Q model as BED = nd [1+ {d/(α/β)}]. For equal biological effect, n_1d_1 [1+{d_1/(α/β)}] = n_2d_2[1+ {d_2 /(α/β)}], i.e. 2 × 30 (1 + 2 /3) = 3 × n_2 (1 + 3/3) giving n_2 = 16.7. If the tissues are early-responding tissues, one has to only assume α/β = 10 (see the following problem).

89. b

G. Treatment Techniques and Treatment Delivery

1. b, d

Here are some sample questions and answers from

Chapter 4: Dose Calculation Methods

49. (Yes / No) For a wedged beam, the majority of the head scatter arises from both the flattening filter and the wedge.

50. (Yes / No) d_{max} increases with increasing beam energy.

51. (Yes / No) Exit dose decreases with increasing beam energies.

52. (Yes / No) For POP of fields, the advantage of using higher MV x-ray beam is lower skin dose and greater dose uniformity across the volume.

53. (Yes / No) The disadvantage of using higher MV x-ray beams is lower dose in the buildup region and problem in treating superficial nodes.

54. (Yes / No) A 5 x 20 field has a greater TMR compared to a 10 x 10 field.

55. (Yes / No) Increasing SSD can decrease the skin dose.

56. (Yes / No). Peak scatter factor is depth dependent.

57. (Yes / No) Peak scatter factor is independent of SSD.

58. (Yes / No) PSF is dependent on beam quality.

59. (Yes / No) The S_c factors are machine independent.

60. (Yes / No) Tray factor exhibits significant field size dependence.

61. (Yes / No) The attenuating filter correction factors always appear in the denominator of the dose equation.

62. (Yes / No) Beam hardening is more for dynamic wedge fields compared to physical wedged fields.

63. (Yes / No) A dynamic wedge does not alter the open field PDD.

64. (Yes / No) The open field and wedge field of a large wedge angle can be combined to produce a wedged field of any desired intermediate angle.

Choose the right answer(s) (more than one may be correct):

(Field sizes are specified in cm unless otherwise specified.)

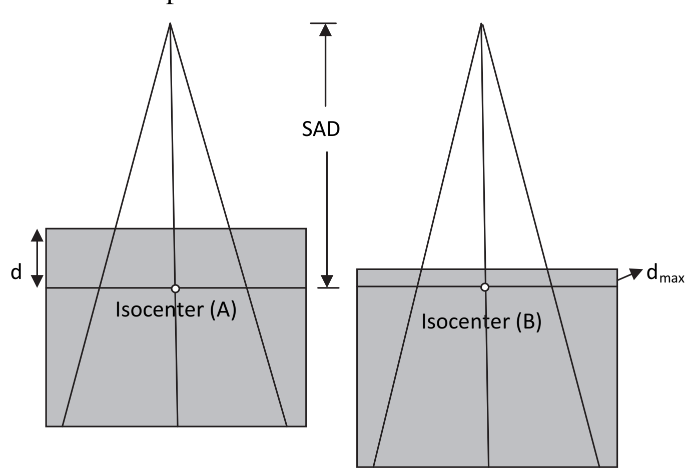
65. A superficial x-ray unit has a cone size of 10 cm diameter and an SSD of 18 cm. To treat a patient with a field size of 14 cm diameter, the required SSD (in cm) is _____.
    a. 36
    b. 30
    c. 25.2
    d. 18
    e. 10

66. A skin lesion is treated using 80 kV, 2 mm Al HVL x-ray beam using a 2 cm diameter cutout in a 3 cm diameter collimator. _____ is the treatment duration (in minutes and seconds) to deliver 450 cGy to the superficial lesion. The following data are given:
the beam calibration is given by D_{cal} (0 cm, 3 cm cone, 15 cm SSD) = 280.4 cGy/min
BSF (3 cm) = 1.14; BSF (2 cm) = 1.11
    a. 10’ 5”
    b. 6’ 20”
    c. 3’ 15”
    d. 1’ 38”
    e. 30”

67. A larger-size skin lesion was treated by the same x-ray beam as in the last problem with an 8 cm cutout in a 10 cm diameter collimator. _____ is the treatment duration (in minutes) to deliver 425 cGy to the superficial lesion. The following data are given:
The beam calibration is given by D_{cal} (0 cm, 10 cm cone, 15 cm SSD) = 246.5 cGy/min
BSF (10 cm) = 1.24; BSF (8 cm) = 1.22
    a. 1.75
    b. 2.8
    c. 4.9
    d. 8.3
    e. 10

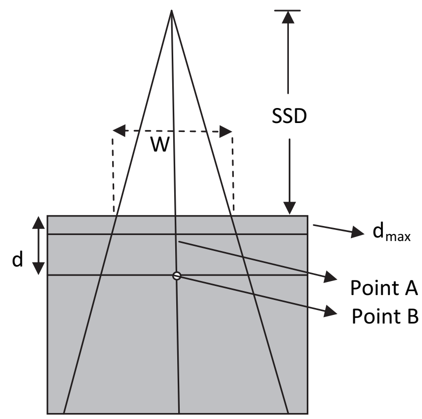
68. Which of the following is a true statement?
    a. TAR increases with increasing SSD.
    b. TAR decreases with increasing SSD.
    c. TAR increases with decreasing field size.
    d. TAR decreases with increasing beam energy.
    e. None of the above are true.

69. In the figure below, TMR is defined as _____.
    a. dose at A / dose at B for the same field size
    b. dose at A / dose at B for two different field sizes
    c. dose at B / dose at A for same field size
    d. dose at B / dose at A for different field sizes
    e. dose at A / dose at A without the phantom



Concept of tissue maximum ratio (TMR)

70. In the figure below, PDD is defined as _____.
    a. dose at A / dose at B with and without phantom
    b. dose at A / dose at B for the same field size
    c. dose at A / dose at B for two different field sizes
    d. dose at B / dose at A for same field size W, and SSD
    e. dose at B / dose at A for different field sizes



Concept of percentage depth dose

71. In an SSD setup of treatment, the dosimetric quantity to be used for MU calculation is _____.
    a. PSF
    b. TMR
    c. TPR
    d. SMR
    e. PDD

72. The dose at depths d and d_{max} measured in a water phantom at the same point and for the same field size represents the quantity _____.
    a. TAR
    b. TPR
    c. TMR
    d. PDD
    e. SMR

73. TMR varies with _____.
    a. field size
    b. SSD
    c. depth
    d. beam quality
    e. none of the above parameters

74. For a clinical x-ray beam, as the field size increases, _____.
    a. the output remains constant
    b. the output increases
    c. PDD increases
    d. scatter contribution decreases
    e. the x-ray energy decreases

49. Yes

50. Yes

51. No

52. Yes

53. Yes

54. No

55. Yes The surface receives less scatter from the linac head.

56. No

57. Yes Being a ratio, the distance corrections cancel out.

58. Yes

59. No One should measure this factor for each linac. The differences in in-air output ratio for the same field size on different machines is primarily attributed to the difference in monitor back scatter.

60. No

61. No It depends on how one derives the MUs from tumor dose to d_{max} dose or vice versa.
$D(d_{max}) = TD(d) / [PDD \times \text{wedge attenuation x tray attenuation}$
$TD(d) = D(d_{max}) \times PDD \times [\text{wedge attenuation} \times \text{tray attenuation}]$
We always use the first equation since we derive d_{max} dose from tumor dose prescription, and we derive MUs from beam calibration.

62. No Since there is no physical wedge present to harden the beam.

63. Yes

64. Yes

65. c

66. d

67. a

68. e

69. a

70. d

71. e

72. c

73. a, c, d

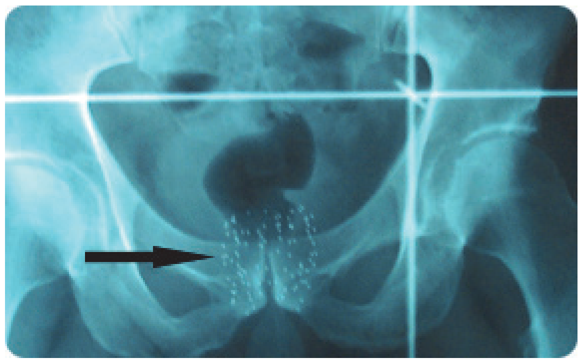
74. b, c

Here are some sample questions and answers from

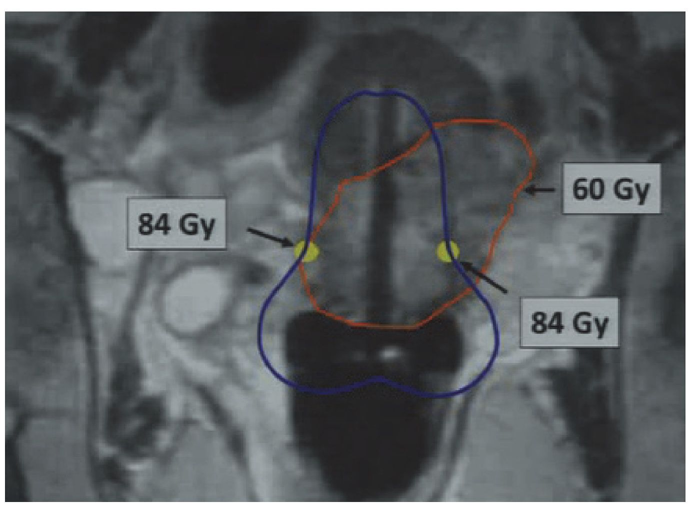
Chapter 5: Brachytherapy

15. The _____ imaging modality is limited to only axial slices.
    a. CT
    b. x-ray film
    c. ultrasound
    d. MRI

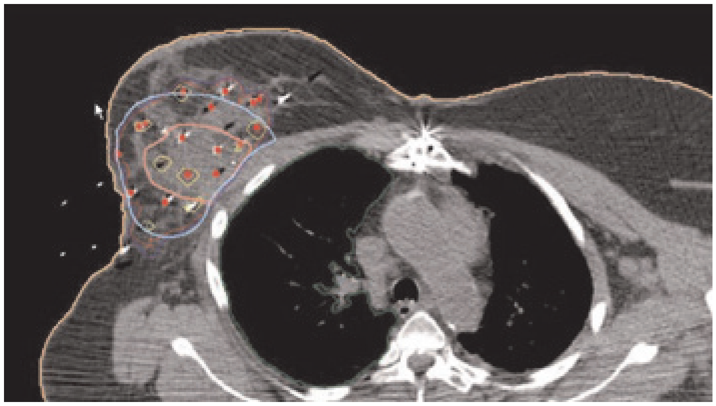
16. The _____ imaging modality was used to take this image of a permanent implant.
    a. x-ray machine
    b. ultrasound
    c. MRI
    d. PET
    e. CT



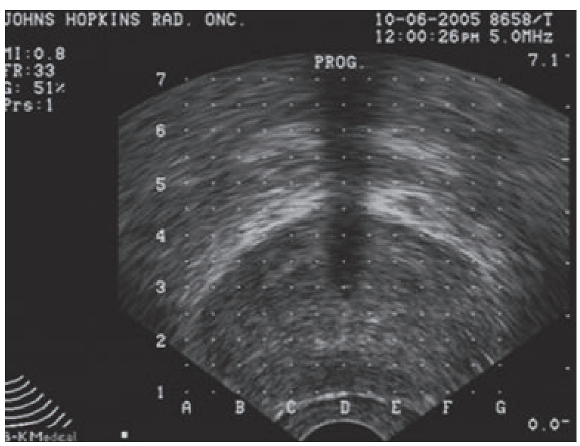
17. The _____ imaging modality was used to take this image which shows Point A and target dose for an intracavitary treatment.
    a. x-ray machine
    b. ultrasound
    c. MRI
    d. PET
    e. CT



18. The _____ imaging modality was used to take this image which shows an interstitial multicatheter brachytherapy implant.
    a. x-ray machine
    b. ultrasound
    c. MRI
    d. PET
    e. CT



19. The _____ imaging modality was used to take this image which shows a scan of the prostate gland.
    a. CT
    b. x-ray films
    c. ultrasound
    d. MRI
    e. PET



20. The imaging modalities that show high temporal and contrast resolution are _____.
    a. CT
    b. x-ray films
    c. ultrasound
    d. MRI
    e. PET

21. The imaging modalities used for real-time imaging include _____.
    a. CT
    b. x-ray films
    c. ultrasound
    d. MRI
    e. PET

15. a

16. a

17. c

18. e

19. c

20. d

21. c

Here are some sample questions and answers from

Chapter 6: Radiation Protection

11. A medical radiation worker's occupational dose limit is 50 mSv. He receives 15 mSv while undergoing a medical examination. _____ is the maximum dose (in mSv) he can receive in his occupation during that year.
   a. 50
   b. (50 – 15)
   c. (50 – 15) – dose from natural background radiation
   d. (50 + 15)
   e. none of the above

12. There are maximum permissible dose limits for an occupational worker or the public, but not for a patient (medical exposure) because _____.
   a. a patient can tolerate any level of exposure
   b. a patient is sick and can be subjected to any dose
   c. a patient undergoes risk but also gets benefit which far outweighs his risk
   d. staff can accept only a certain amount of risk since the benefit goes to society

13. A radiation worker working in a high natural background region receive an annual dose of 10 mSv. He also receives a dose of 5 mSv in a medical examination. His occupational dose limit is 50 mSv, so he can receive a maximum dose of _____ mSv during the year.
   a. 50
   b. 50 – 10
   c. 50 – 5
   d. 50 – 10 – 5
   e. 50 + 10 – 5

C. Time, Distance, and Shielding (and ALARA Concepts)

The concepts of time, distance, and shielding play central roles in optimizing the dose received by exposed individuals. The dose received by a radiation worker is proportional to the time during which he is exposed, how far (or distant) he is from the source, and how much shielding is between the source of radiation and the radiation worker. All three parameters come into play while handling brachytherapy sources. Time and distance play an important role for the staff working inside fluoroscopy rooms performing procedures on a patient under fluoroscopic guidance. Shielding greatly controls the exposure of radiation workers in radiotherapy.

Circle the right answer (Yes or No):

1. (Yes / No) Radiation dose received by staff working with radiation must be as low as reasonably achievable.

2. (Yes / No) Adhering to the regulatory dose limits ensures that the doses received are at ALARA levels.

3. (Yes / No) A radiation worker receives a dose of 20 mSv every year. Is his exposure within legal limits?

4. (Yes / No) A medical radiation worker receives 20 mSv from the age of 18 until he retires at the age of 60. Does he exceed the NCRP recommended cumulative exposure for the radiation worker?

5. (Yes / No) A medical radiation worker receives 20 mSv from the age of 18 until he retires at the age of 64. Does he exceed the ICRP recommended cumulative exposure for the radiation worker?

Choose the right answer(s) (more than one may be correct):

6. The concept of ALARA is based on the conservative assumption involved in the current philosophy of radiation protection that _____.
   a. radiation at any level involves an element of risk
   b. low doses do not cause any harm
   c. low doses are beneficial to the exposed individual
   d. it is easy to protect against low doses but not high doses
   e. low doses increases the efficiency of the radiation worker

7. The basic philosophy of radiation protection that stems from the ALARA concept is _____.
   a. justification
   b. optimization
   c. dose limitation
   d. training
   e. regulation

8. "As low as reasonably achievable" means taking _____ factors into account to decide on the ALARA.
   a. social
   b. technical
   c. economic
   d. practical
   e. all the above

9. Dose equals _____.
   a. dose rate
   b. dose rate / time
   c. dose rate $\times$ time
   d. dose rate $\times$ time^2
   e. none of the above

10. A radiation worker stands in a place where the radiation level in air kerma rate is 10 μGy/h. If he is in this field for 15 minutes, he receives a total exposure of _____ μGy.
    a. 1
    b. 2.5
    c. 5
    d. 10
    e. 40

11. A technologist can stay _____ in a 10 mSv/hr radiation field if he wishes to limit his dose to 1 mSv.
    a. 1 hr
    b. 30 min
    c. 10 min
    d. 6 min
    e. 10 sec

12. Increasing one's distance from a radioactive source _____.
    a. increases one's exposure
    b. increases one's exposure as the square of the distance from the source
    c. decreases one's exposure
    d. decreases one's exposure as the distance from the source (α 1/d)
    e. decreases one's exposure as the square of the distance from the source (α 1/d^2)

11. a. Medical exposure, occupational exposure, and natural background exposure belong to different "bank accounts" and cannot be in any way connected with one another since the justifications for these exposures are different.

12. c, d. The staff work for the benefit of the society and so their risks should be of the order of risk involved in any "safe" industry (not high-risk industries).

13. a

C. Time, Distance, Shielding (and ALARA Concepts)

1. Yes ALARA is not only a safety principle, but it is a regulatory requirement for all radiation safety programs.

2. No. The average annual regulatory dose limit for the medical radiation worker is 20 mSv, but medical radiation workers receive only a few mSv in a year, so unoptimized doses are totally unacceptable.

3. Yes But totally unacceptable since the ALARA qualified dose limit is much less than the legal limit for almost all radiation workers.

4. Yes

5. No

6. a

7. a, b, c

8. e

9. c

10. b

11. d

12. c, e

Here are some sample questions and answers from

Chapter 7: Quality Assurance

VII. Quality Assurance

A. Treatment Delivery Equipment (External Beam Therapy and Brachytherapy)

Circle the right answer (Yes or No):

1. (Yes / No) Each model of radiation therapy equipment, simulator, or remote afterloading brachytherapy equipment must be type approved before granting approval for patient use.

2. (Yes / No) Any type of approved equipment need not be individually acceptance tested at hospital sites before putting them to use on patients.

3. (Yes / No) Acceptance tests are carried out to ensure that the equipment conforms to some national or international performance standards set for the equipment.

4. (Yes / No) It is the responsibility of the manufacturer to demonstrate compliance of its equipment to international standards (e.g., IEC, IAEA, AAPM, etc.).

5. (Yes / No) Radiation therapy (or brachytherapy) equipment that complies with any national or international standard would be safe for patient treatment.

6. (Yes / No) Before carrying out acceptance tests, a radiation protection survey of the installation room must be carried out.

7. (Yes / No) It is not necessary to carry out periodic QA on radiation therapy equipment that has been type approved and acceptance tested for patient use.

8. (Yes / No) The beam data of any machine can be obtained from any hospital having the same model of the equipment.

9. (Yes / No) All the QA tests on radiation therapy equipment must be carried out with the same frequency.

10. (Yes / No) Beam quality of an accelerator beam must be established only during commissioning measurements. It need not be monitored periodically.

11. (Yes / No) The beam output and beam uniformity must be checked with respect to gantry angle.

12. (Yes / No) The wedge transmission factors given by the manufacturer need no verification.

13. (Yes / No) The collimator axis does not shift with respect to collimator rotation.

14. (Yes / No) The dwell position accuracy of a remote afterloading ^{192}Ir HDR unit can be checked by taking an auto radiograph.

15. (Yes / No) The air kerma strength of a brachytherapy source can be measured using a calibrated well-type ionization chamber.

16. (Yes / No) In a remote afterloading brachytherapy unit, the source travel time is independent of the source catheter length.

17. (Yes / No) The accuracy of the timer of a remote afterloading ^{192}Ir HDR unit is difficult to verify.

Choose the right answer(s) (more than one may be correct):

18. Acceptance tests are carried out on radiation therapy or brachytherapy equipment to ensure that the equipment conforms to _____.
    a. state regulations
    b. standards set by any professional body in the country's protocol (e.g., AAPM)
    c. manufacturer's specifications
    d. none of the above

19. After acceptance testing and following commissioning, _____ measurements must be carried out.
    a. beam data
    b. beam calibration
    c. radiation protection installation survey
    d. none of the above

20. Functional performance of radiation therapy equipment can _____.
    a. not vary with time
    b. change due to malfunctions of system electronics or components
    c. change due to wear and tear on the equipment
    d. change due to environmental conditions

21. The main features of radiation therapy equipment that need be tested are _____.
    a. mechanical characteristics
    b. electrical characteristics (including emergency beam off switches and door interlocks)
    c. radiological characteristics
    d. none of the above

22. _____ in order to ensure radiation safety of patients, staff, and the public.
    a. Warning signs have to be displayed in radiation areas
    b. Radiation on/off lights must be in place at the treatment room door
    c. Emergency beam off switches must be tested daily
    d. Door interlocks must be tested daily

23. Field uniformity can be checked by measuring _____.
    a. output
    b. field size dependence of output
    c. flatness
    d. symmetry

VII. Quality Assurance ANSWERS

A. Treatment Delivery Equipment (External Beam Therapy and Brachytherapy)

1. Yes Type approval is the process of a regulatory body approving any radiation-generating equipment, after testing, certifying that the equipment is safe to install for clinical use. In many countries only type-approved equipment can be installed for patient use.

2. No The safety of every piece of equipment has to be ensured before being put to clinical use.

3. Yes

4. Yes

5. Yes

6. Yes It is always good practice to ensure radiation safety of any installation before switching on the unit for any measurement.

7. No Periodic QA is essential to ensure that the equipment continues to conform to the performance standards.

8. No The beam data are unique for each machine and so must be generated for each unit before it is put to clinical use.

9. No The frequency of each test depends on its relative stability and impact on patient treatment.

10. No The beam quality and output must be monitored on a daily basis since any drift in beam stability can affect these parameters and accelerator beams are not as stable as, say, a ^{60}Co beam.

11. Yes

12. No The user must make use of experimentally measured wedge transmission factors.

13. No The collimator axis may shift with respect to collimator rotation but the shift must be within the specified limits (See AAPM TG-40 report).

14. Yes

15. Yes

16. No

17. No

18. a, b, c

19. a, b, c

20. b, c

21. a, b, c

22. a, b, c, d

23. c, d