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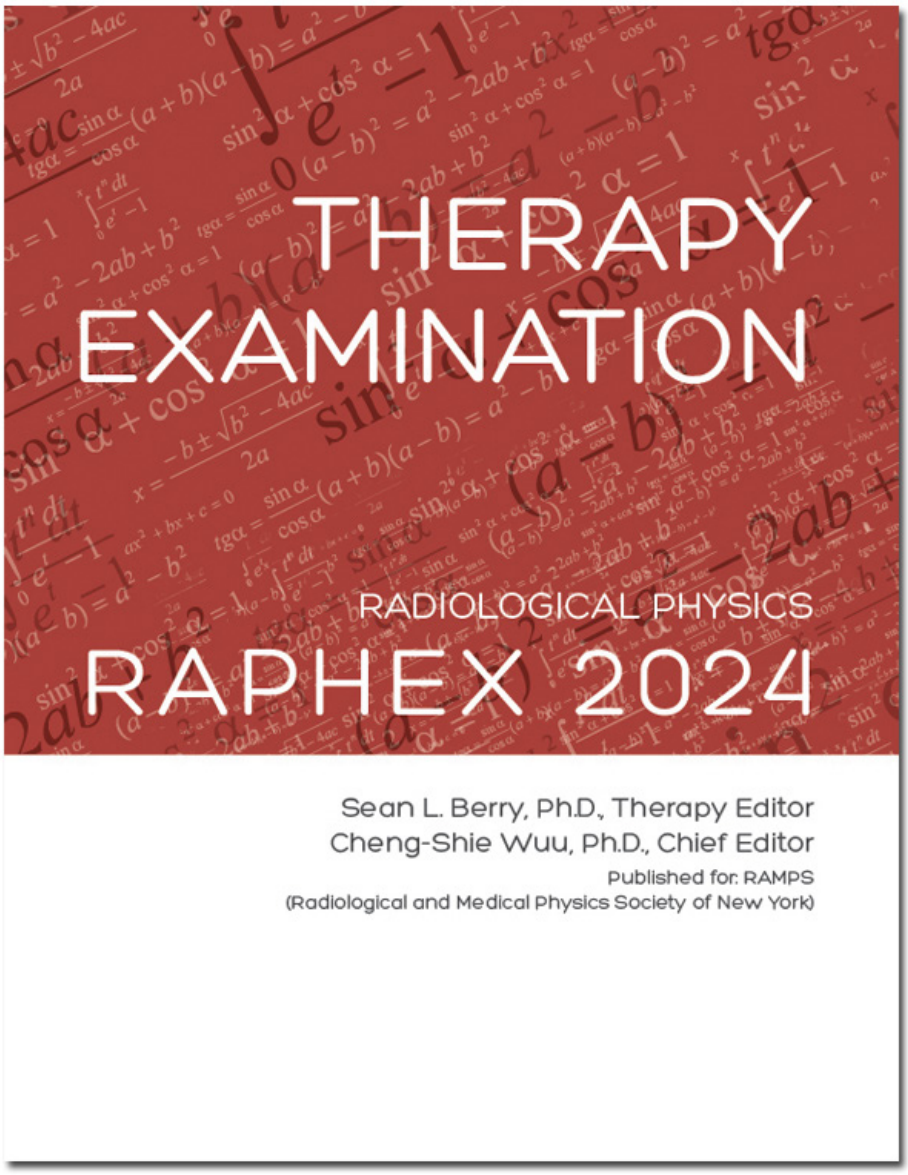

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The exam content was updated in 2016 to match the syllabi for teaching Radiation Oncology residents published by the The American Society for Radiation Oncology (ASTRO) Physics Core Curriculum Subcommittee (PCCSC). The numbers of questions for each subject are approximately related to the number of teaching hours allocated to each subject.

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If you are taking RAPHEX under exam conditions, your proctor will give you instructions on how to fill out your examinee and site IDs on the answer sheet.

- You have **3 HOURS** to complete the exam.
- Non-programmable calculators may be used.
- Choose the most complete and appropriate answer to each question.

We urge residents to review the exam with their physics instructors. Any comments or corrections are appreciated and should be sent to:

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T1. All of the following are SI units that are derived from other base SI units, EXCEPT:

A. gray
B. joule
C. newton
D. kilogram
E. becquerel

T2. Which of the following factors limits the maximum energy that can be imparted to a proton in a cyclotron?

A. charge
B. the gap between the two dees
C. variation in mass with velocity
D. potential difference between the dees
E. the size of the two dees

T3. Which quantity is conserved in an inelastic collision of two bodies having the same temperature?

A. kinetic energy
B. temperature
C. momentum
D. speed of one body relative to the other
E. position of the center of mass of the two bodies

T4. What is the wavelength of a light wave in a vacuum with a frequency of 3000 MHz?

A. 0.001 m
B. 0.01 m
C. 0.1 m
D. 1.0 m
E. 10 m

T5. What expression defines the energy (E) of a photon? Note h = Planck's constant, f = frequency, λ = wavelength, c = speed of light in a vacuum.

A. $E = hf$
B. $E = h / f$
C. $E = hc / f$
D. $E = hf / \lambda$
E. $E = h\lambda / c$

T6. Approximately how many times larger is the mass of a proton than that of an electron?

A. 1.8
B. 18
C. 180
D. 1800
E. 18000

T7. What two radioactive decay processes compete with one another?

A. internal conversion, gamma ray emission
B. positron decay, negatron decay
C. negatron decay, electron capture
D. alpha decay, gamma ray emission
E. negatron decay, alpha decay

T8. Which of the following best describes the parent–daughter relationship between $^{226}Ra \rightarrow {}^{222}Rn$?

A. temporal equilibrium
B. secular equilibrium
C. transient equilibrium
D. positive equilibrium
E. no equilibrium

T9. Given the following activation equation, what is the missing atom?

$$^{4}He + {}^{14}N = \_\_\_\_ + {}^{1}H$$

A. ^{18}C
B. ^{16}O
C. ^{17}O
D. ^{18}O
E. ^{18}F

T10. The atomic number is the number of _____ in the nucleus, while the mass number is the number of _____.

A. protons, nucleons
B. protons, neutrons
C. protons, electrons
D. electrons, nucleons
E. electrons, protons

T11. Which of the following particles can have a bremsstrahlung interaction?

A. neutron
B. positron
C. neutrino
D. anti-neutrino
E. photon

T12. What component is responsible for increasing the input voltage by orders of magnitude to the kilovoltage range as required for diagnostic x-ray production?

A. capacitor
B. rectifier
C. transformer
D. cathode
E. anode

T13. What increases when a polyenergetic kilovolt (kV) x-ray beam is filtered?

A. intensity
B. half-value layer
C. maximum photon energy in the beam
D. energy of characteristic peaks
E. electron contamination

T14. What increases when the anode angle in an x-ray tube increases?

A. size of the actual focal spot
B. size of the effective focal spot
C. spatial resolution
D. anode heel effect
E. variation in x-ray intensity along the length of the x-ray tube

T15. What is the purpose of an x-ray tube's oil bath?
- A. absorb heat from the anode
- B. prevent stray electrons from striking nontarget components of the tube
- C. modulate the tube dose rate
- D. reduce the size of the effective focal spot
- E. prevent the anode heel effect

T16. What is the average photon energy resulting from the decay of Co-60?
- A. 0.380 MeV
- B. 0.412 MeV
- C. 0.662 MeV
- D. 1.25 MeV
- E. 1.33 MeV

T17. All of the following occur when a linac is changed from x-ray mode to electron mode, EXCEPT:
- A. scattering foil is placed in the beam
- B. target is removed
- C. monitor chamber is removed
- D. electron applicator is attached
- E. beam current decreases

T18. What function does a thyratron perform in a linear accelerator?
- A. multiplication to high voltage
- B. voltage rectification
- C. high-speed switch and controlled rectifier
- D. thermionic emission
- E. radio frequency (RF) amplification

T19. What is the purpose of a linear accelerator interlock?
- A. automate accelerator performance
- B. speed up accelerator operation
- C. prevent machine operation if necessary conditions are not met
- D. reduce radiation levels around the accelerator

T20. What does the bending magnet in a linac direct?
- A. electron beam exiting the electron gun toward the accelerator structure
- B. RF power exiting the klystron toward the RF waveguide
- C. electron beam exiting the accelerator structure toward the target
- D. photon beam exiting the target toward the exit window
- E. electron beam exiting the scattering foil toward the exit window

T21. What is the typical amount of intraleaf transmission for multileaf collimators (MLCs) on modern linear accelerators?
- A. 0%
- B. 1 to 3%
- C. 6 to 8%
- D. 11 to 15%
- E. 20 to 24%

T22. The tongue-and-groove design of MLC leaves is used to reduce which of the following?
- A. variability of the penumbra across different field sizes
- B. leakage through the MLC leaves
- C. leakage between adjacent MLC leaves
- D. dosimetric leaf gap
- E. leaf travel speed limitations

T23. Compared to 10 MV flattened beams, 10 MV flattening filter free (FFF) beams:
- A. have a higher surface dose
- B. are slower to deliver
- C. have a larger out-of-field dose
- D. produce more neutrons
- E. have a larger maximum field size

T24. Which of the following is a type of indirectly ionizing radiation?
- A. electron
- B. proton
- C. photon
- D. carbon ion
- E. alpha particle

T25. Why is iodine an effective contrast agent in diagnostic radiography?
- A. iodine radioactive decay produces extra photons at the detector
- B. iodine has a higher probability of photoelectric effect than soft tissue
- C. iodine generates more Compton scatter than soft tissue
- D. iodine generates more Rayleigh scatter than soft tissue
- E. iodine has a higher probability of pair production than soft tissue

T26. Which type of photon interaction is dominant in brain tissue for the photon energies utilized in a Gamma Knife stereotactic radiosurgery (SRS) treatment?
- A. Rayleigh scattering
- B. photoelectric effect
- C. Compton scattering
- D. pair production
- E. photonuclear disintegration

T27. For the same prescribed dose to a soft tissue tumor in the head and neck region, which anatomical structure will have the greatest increase in dose for a treatment using orthovoltage x-rays relative to a treatment using MV x-rays?
- A. muscle
- B. fat
- C. lung
- D. bone
- E. skin

T28. Neutron dose is potentially a concern for which of the following?
- A. LDR implant using I-125
- B. HDR treatment using Ir-192
- C. Gamma Knife treatment using Co-60
- D. breast boost treatment using 9 MeV electrons
- E. prostate treatment using 18 MV X-rays

T29. A material's total linear attenuation coefficient can be a function of any of the following, EXCEPT:
- A. atomic number of the material
- B. density of the material
- C. energy of the photon beam
- D. energy of the electron beam

T30. Which of the following is a possible consequence of a photoelectric interaction between a photon and an atom?
- A. the scattered photon loses an amount of energy equal to the binding energy of the electron
- B. the scattered photon leaves the interaction with the same amount of energy as the incident photon
- C. the ejected electron has an energy equal to that of the incident photon
- D. no electrons are ejected from the atom
- E. characteristic x-rays or Auger electrons are emitted from the atom when the vacancy in the ejected electron's orbital is filled

T31. Doubling which parameter will increase the stopping power the most?
- A. charge of the incident particle
- B. atomic number of the target material
- C. mass of the incident particle
- D. mass of the target material
- E. velocity of the incident particle

T32. What is the activity of a radionuclide sample containing 10^5 atoms ($T_{1/2} = 6.93 \times 10^3$ seconds)?
- A. 0.693 Bq
- B. 1 Bq
- C. 6.93 Bq
- D. 10 Bq
- E. 69.3 Bq

T33. What term describes the quotient of dR by da where dR is the radiant energy incident on a sphere of cross-sectional area da?
- A. fluence
- B. energy fluence
- C. fluence rate
- D. energy fluence rate
- E. planar fluence

T34. For a mono-energetic beam of particles with energy E, how are fluence (Φ) and energy fluence (Ψ) related?
- A. $\Psi = \Phi$
- B. $\Psi = \Phi / E$
- C. $\Psi = \Phi E$
- D. $\Psi = (\Phi / E)^2$
- E. $\Psi = (\Phi E)^2$

T35. The AAPM Task Group 51 absolute dose calibration protocol can be used for all of the following types of radiation beams, EXCEPT:
- A. ^{60}Co
- B. ^{192}Ir
- C. 4 MeV electrons
- D. 2.5 MV x-rays
- E. 25 MV x-rays

T36. When calibrating a linac using the AAPM Task Group 51 calibration protocol, all of the following parameters vary with the energy of the photon beam being calibrated, EXCEPT:

A. $N_{D,w}^{Co-60}$
B. $\%dd(10)_x$
C. k_Q
D. the amount of charge collected by the ion chamber
E. all of the above depend on the energy of the linac being calibrated

T37. All of the following are acceptable uses of electronic portal imaging devices (EPIDs), EXCEPT:

A. pretreatment patient-specific quality assurance
B. pretreatment portal imaging
C. *in vivo* transit dosimetry measurements during treatment
D. annual beam output measurements
E. relative beam constancy checks such as beam profiles

T38. Modern EPIDs utilize what type of radiation detector?

A. ion chambers
B. metal-oxide-semiconductor field-effect transistors (MOSFETs)
C. scintillators and photodiodes
D. silver halide–based radiographic film
E. radiochromic film

T39. All of the following detectors can be used for *in vivo* dosimetry, EXCEPT:

A. MOSFETs
B. optically stimulated luminescent dosimeters (OSLDs)
C. diodes
D. thermoluminescent dosimeters (TLDs)
E. ion chambers

T40. After irradiation, OSLDs are read out by applying _____, whereas TLDs are read out by applying _____.

A. heat, light
B. light, pressure
C. light, heat
D. light, current
E. current, heat

T41. Radiation measurement using a diode is affected by all of the following, EXCEPT:

A. beam energy
B. temperature
C. atmospheric pressure
D. field size
E. beam angle of incidence

T42. If the raw transmission values for radiochromic films exposed to 0 centigray (cGy) and 400 cGy are 2×10^5 and 2×10^3, respectively, what is the net optical density corresponding to 400 cGy?

A. 0
B. 1
C. 2
D. 3
E. 4

T43. Why is the geometric penumbra of a 15-cm-long circular SRS cone smaller than a MLC's geometric penumbra?

A. less scattering
B. circular field
C. larger source-to-diaphragm distance
D. less leakage
E. more attenuation

T44. A superficial lesion could be treated either with 100 kVp x-rays at 6 cm source-to-surface distance (SSD) or 4 MeV electrons at 100 cm SSD. Why is maintaining the SSD used in the dose calculation more crucial when treating with these x-rays than when using these electrons?

A. 100 kVp x-rays are absorbed in air
B. 4 MeV electrons are absorbed in air
C. inverse square law effects are larger at shorter SSDs
D. 100 kVp x-rays will deliver a greater surface dose
E. 4 MeV electrons will deliver a greater surface dose

T45. What is the average energy of a 15 MV linac-produced photon beam at the surface of a patient?

A. 2.5 MeV
B. 5.0 MeV
C. 7.5 MeV
D. 10.0 MeV
E. 15.0 MeV

T46. As the distance from the megavoltage photon beam source to the surface is decreased, the dose rate at d_{max} will _____ and the percent depth dose (PDD) at 10 cm depth will _____.

A. increase; decrease
B. decrease; decrease
C. increase: increase
D. decrease; increase
E. increase; remain the same

T47. As the collimator setting for a linac-produced MV photon beam is decreased, which of the following remains unchanged?

A. collimator scatter factor (S_c)
B. phantom scatter factor (S_p)
C. ionizing potential used to accelerate the beam
D. percent depth dose (PDD)
E. tissue maximum ratio (TMR)

T48. Superposition/convolution algorithms will result in the most significant improvement in dose calculation accuracy over pencil beam convolution algorithms for which of the following body sites?

A. brain
B. head and neck
C. lung
D. liver
E. prostate

T49. What is the process of evaluating the entire radiotherapy workflow chain by taking an anthropomorphic phantom from simulation through planning, treatment delivery, and dose measurement called?

A. process mapping
B. end-to-end testing
C. failure modes and effects analysis
D. statistical process control
E. root-cause analysis

T50. For treatment of the left breast using tangent fields and a deep-inspiration breath-hold (DIBH) technique, compared to free breathing, all of the following are true, EXCEPT:

A. less heart tissue is irradiated
B. same volume of lung is irradiated
C. lung volume and positioning are more reproducible
D. it requires a patient who can actively participate in the process
E. optical surface imaging can be used for monitoring the level of inspiration

T51. How is the tissue maximum ratio (TMR) defined?

A. dose at a specified depth in a phantom with a low-energy MV photon beam to the dose at the same depth in a phantom with a high-energy MV beam
B. dose at a specified depth in a phantom to the dose at the depth of maximum dose in a phantom, where the phantom is moved between the measurements such that both of the measurement points are at the same distance from the source
C. dose at a specified depth in a phantom to the dose at the depth of maximum dose in a phantom, where the phantom is kept at the same source-surface distance (SSD) between the measurements such that the measurement points are at different distances from the source
D. dose at a specified depth in a phantom to the dose free in air, where both of the measurement points are at the same distance from the source
E. dose at the depth of maximum dose in a phantom to the dose free in air, where both of the measurement points are at the same distance from the source

T52. For a MV photon beam, the collision kerma is _____ the dose in the buildup region and _____ the dose in the region of transient charged particle equilibrium.

A. greater than; greater than
B. greater than; less than
C. less than; the same as
D. less than; greater than
E. less than; less than

T53. How is MV beam flatness defined? Note that D_{max} is the maximum dose and D_{min} is the minimum dose both within the central 80% of the beam width.

A. $100\% \times (D_{max} - D_{min}) / (D_{max} - D_{min})$
B. $100\% \times (D_{max} + D_{min}) / (D_{max} - D_{min})$
C. $100\% \times (D_{max} - D_{min}) / (D_{max} + D_{min})$
D. $100\% \times (D_{max} - D_{min}) / (2 \times D_{max} + D_{min})$
E. $100\% \times (D_{max} + D_{min}) / (2 \times D_{max})$

Use the following table for questions T54 and T55:

6 MV Photon PDD table (100 cm SSD)				
Field Size	**5 × 5 cm^2**	**10 × 10 cm^2**	**15 × 15 cm^2**	**20 × 20 cm^2**
S_c	0.962	1.000	1.021	1.030
S_p	0.983	1.000	1.013	1.023
PDD(d = 1.5 cm)	100%	100%	100%	99.7%
PDD(d = 3 cm)	94.4%	94.8%	94.8%	94.9%
PDD(d = 6 cm)	80.1%	82.1%	83.2%	83.6%
PDD(d = 9 cm)	67.5%	70.4%	72.1%	73.1%
Reference output = 1.0 cGy/MU at d_{max} for 10 × 10 cm^2 at 100 SSD				

T54. How many monitor units (MU) are needed to deliver 300 cGy per fraction to a depth of 6 cm with a single 6 MV x-ray beam (d_{max} = 1.5 cm) at 100 cm SSD with a collimator setting of 12 × 20 cm^2 shaped, with MLC, to a field size of 8.6 × 12 cm^2?

A. 318
B. 338
C. 348
D. 358
E. 408

T55. If the dose at a depth of 6 cm is 300 cGy using the beam geometry described above, what is the dose at a depth of 3 cm?

A. 260
B. 346
C. 367
D. 381
E. 426

Use the following table for questions T56 and T57:

6 MV Photon TMR table				
Field Size	**5 × 5 cm^2**	**10 × 10 cm^2**	**15 × 15 cm^2**	**20 × 20 cm^2**
S_c	0.962	1.000	1.021	1.030
S_p	0.983	1.000	1.013	1.023
TMR(d = 1.5 cm)	1.000	1.000	1.001	1.001
TMR(d = 4 cm)	0.939	0.951	0.955	0.958
TMR(d = 8 cm)	0.804	0.837	0.853	0.863
TMR(d = 12 cm)	0.678	0.721	0.746	0.764
Reference output = 1.0 cGy/MU at d_{max} for 10 × 10 cm^2 at a source-calibration point distance of 100 cm SAD				

T56. How many MU per beam are needed to deliver 200 cGy per fraction to a midplane depth of 8 cm with equally weighted parallel-opposed anterior–posterior 6 MV x-ray beams (d_{max} = 1.5 cm) at 100 cm SAD to the beam's isocenter at midplane depth? The collimator setting is 24 × 17.2 cm^2 shaped, with MLC, to a field size of 12.8 × 18 cm^2.

A. 96
B. 112
C. 119
D. 126
E. 131

T57. If the dose at a midplane depth of 8 cm using the beam geometry described above is 200 cGy, what is the dose at an anterior depth of 4 cm?

A. 194 cGy
B. 198 cGy
C. 200 cGy
D. 203 cGy
E. 205 cGy

T58. A symmetric field 20 cm long matches with a symmetric field 15 cm long at a depth of 5 cm, all at 100 cm SAD, what is the gap on the skin?

A. 0 cm
B. 0.325 cm
C. 0.500 cm
D. 0.875 cm
E. 1.250 cm

T59. What wedge angle is best utilized for two beams with a hinge angle of 135º?

A. 22.5º
B. 45º
C. 67.5º
D. 90º
E. 112.5º

T60. A MV photon beam traverses 3 cm of muscle ($\rho = 1$ g/cm^3), 3 cm of lung ($\rho = 0.25$ g/cm^3), and then 2 cm of muscle ($\rho = 1$ g/cm^3). What is the approximate radiological path length?

A. 5.75 cm
B. 8.00 cm
C. 10.25 cm
D. 13.75 cm
E. 17.00 cm

T61. The backscatter factor (BSF) is a special case of what other factor for the situation where the reference depth is d_{max} on the central axis of the beam?

A. tissue-air ratio (TAR)
B. tissue-maximum ratio (TMR)
C. tissue-phantom ratio (TPR)
D. off-axis ratio (OAR)
E. percent-depth dose (PDD)

T62. How does the surface dose vary as the megavoltage electron beam energy increases?

A. increases
B. decreases
C. remains the same
D. independent of beam energy
E. insufficient information given to determine the relationship

T63. When treating with a 10 cm diameter electron beam, dose coverage at the deepest portion of a tumor can be improved by:

A. adding a second, opposed electron beam
B. increasing the cutout diameter
C. increasing the bolus thickness
D. increasing the energy of the electron beam
E. increasing the air gap

T64. For an electron beam normalized to its d_{max} point, if 1000 cGy is prescribed to the 90% isodose line, what is the maximum dose?

A. 810 cGy
B. 900 cGy
C. 1000 cGy
D. 1090 cGy
E. 1111 cGy

T65. The x-ray contamination dose to a patient from a 9 MeV electron beam ranges between _____% and is mainly contributed by bremsstrahlung interactions of electrons with the _____.

A. 0.5 and 1; body tissues
B. 0.5 and 1; linac head
C. 2 and 5; body tissues
D. 2 and 5; linac head
E. 2 and 5; couch

T66. Compared to a 6 MeV electron beam, the 80% isodose line of a 16 MeV electron beam exhibits lateral _____, which becomes more pronounced with _____ field sizes.

A. constriction; smaller
B. constriction; larger
C. expansion; smaller
D. expansion; larger

T67. All of the following changes to a 12 MeV electron beam with a 10 cm diameter circular cutout at 100 cm SSD will significantly affect the PDD, EXCEPT:

A. reduce cutout diameter to 2 cm
B. introduce 45 degrees of beam obliquity
C. increase SSD to 110 cm
D. reduce electron energy to 9 MeV

T68. The Winston-Lutz test is designed to determine that what is within tolerance?

A. MLC positioning accuracy
B. CBCT geometric accuracy
C. correlation of internal respiratory position with external surrogate
D. uncertainty in the localization of the radiation isocenter
E. end-to-end dose delivery accuracy

T69. According to AAPM Task Group 203, pacemaker doses greater than what amount are categorized as "high risk" in 6 MV photon-based radiotherapy?

A. 0.5 Gy
B. 1 Gy
C. 2 Gy
D. 3 Gy
E. 5 Gy

T70. According to AAPM Task Group 142 and AAPM Medical Physics Practice Guideline 8a, on linear accelerator performance tests, what is the tolerance for the daily test of x-ray output constancy?

A. 0.5%
B. 1%
C. 2%
D. 3%
E. 5%

T71. According to AAPM Task Group 142 and AAPM Medical Physics Practice Guideline (MPPG) 8a, on linear accelerator performance tests, how often should photon monitor unit (MU) linearity be checked?

A. daily
B. weekly
C. monthly
D. quarterly
E. annually

T72. All of the following are functions fulfilled by the record and verify system, EXCEPT:

A. record the treatment delivered to the patient
B. independently verify the accuracy of the monitor unit calculation
C. send the technical parameters of the treatment plan to the treatment machine
D. display the patient's name, date of birth, and face photo
E. ensure plans have sufficient approval status for treatment

T73. All of the following are provided in the Digital Imaging and Communications in Medicine (DICOM) standard, EXCEPT:

A. machine worklist or queue
B. patient image transfer
C. radiotherapy plan transfer to machine
D. direct control of linear accelerator
E. standardized image compression algorithms

T74. All of the following are components of a DICOM element inside a DICOM Dataset, EXCEPT:

A. tag (group and element numbers)
B. edit date
C. value representation
D. value length
E. value field

T75. For IMRT leakage barrier calculations, leakage workload (W_L) can be estimated from primary workload (W_P). W_L (IMRT) = C W_p (IMRT), where C ranges from:

A. 0.2 to 1
B. 1 to 1.5
C. 2 to 10
D. 10 to 15
E. 15 to 20

T76. What is the most appropriate meter to measure photon dose rate beyond a shielded barrier?

A. neutron meter
B. ion chamber array
C. free-air ionization chamber
D. Geiger-Muller survey meter
E. ion chamber survey meter

T77. Changes in all of the following would result in a change in the required minimum thickness of a secondary barrier in a linac vault, EXCEPT:

A. the distance from the linac isocenter to the point being shielded
B. the type of occupant of the area being shielded
C. the frequency of occupation of the area being shielded
D. the frequency at which the linac is directed at the barrier
E. the photon energies used by the linac

T78. When designing shielding for a vault for a 6 MV linac, how many additional tenth value layers should be added to adequately shield for neutrons?

A. 0
B. 0.5
C. 1
D. 2
E. 10

T79. What is the shielding design goal in terms of the dose equivalent rate in any one hour for an uncontrolled area recommended by National Council on Radiation Protections and Measurements (NCRP) 151?

A. 0.01 mSv
B. 0.02 mSv
C. 0.05 mSv
D. 0.10 mSv
E. 0.50 mSv

T80. According to the Nuclear Regulatory Commission (NRC), workers likely to receive greater than what percent of the occupational dose limit should be routinely monitored?

A. 1%
B. 5%
C. 10%
D. 25%
E. 50%

T81. Changing what parameter in a CT protocol would alter the Hounsfield unit (HU) to density table for CT scans taken with that protocol?

A. slice thickness
B. mAs
C. kVp
D. reconstructed field of view
E. pitch

T82. When does aliasing occur in radiographic imaging?

A. the signal-to-background ratio is degraded by increased noise
B. an entire detector row in the flat panel fails
C. the mAs saturates the imager
D. the spatial sampling rate is more than twice the highest spatial frequency of the object being imaged
E. the spatial sampling rate is less than twice the highest spatial frequency of the object being imaged

T83. What images can be used to accurately account for tumor motion due to respiratory motion in the contouring of the internal target volume (ITV) for a hypodense liver lesion?

A. maximum-intensity projection (MIP) image from 4DCT
B. minimum-intensity projection (MinIP) image from 4DCT
C. target visualized on the phase 50% CT from 4DCT
D. target visualized on free-breathing CT

T84. What is the purpose of tube current modulation in a CT acquisition?

A. avoid excessive patient dose
B. reduce scan pitch
C. improve scan resolution
D. increase scan field of view
E. enable respiratory gated scan acquisition

T85. Which of the following CT window/level presets has the highest HU level?
- A. abdomen
- B. bone
- C. breast
- D. lung
- E. pelvis

T86. For the same field of view, what increases when the voxel size in a CT scan increases?
- A. image noise
- B. spatial resolution
- C. low-contrast resolution
- D. data file size
- E. reconstruction time

T87. A 4DCT at simulation would be most useful for which of the following disease sites?
- A. brain
- B. liver
- C. prostate
- D. head and neck
- E. extremity

T88. What is detected by the imaging coil during magnetic resonance imaging (MRI)?
- A. RF waves emitted from nuclei within the patient
- B. RF waves generated within the scanner and transmitted through the patient
- C. acoustic waves generated within the scanner and transmitted through the patient
- D. gamma rays emitted from nuclei within the patient
- E. gamma rays generated within the scanner and transmitted through the patient

T89. On a T1-weighted MRI, _____ displays bright and _____ displays dark.
- A. fluid, fat
- B. fluid, bone
- C. bone, fat
- D. fat, fluid
- E. bone, fluid

T90. All of the following are sources of geometric distortion in MRI, EXCEPT:
- A. gradient nonlinearity
- B. static field inhomogeneity
- C. air cavities
- D. metallic implants
- E. respiratory motion

T91. All of the following isotopes can be used for PET imaging, EXCEPT:
- A. ^{18}F
- B. ^{11}C
- C. ^{68}Ga
- D. ^{64}Cu
- E. ^{125}I

T92. All of the following quantities can be determined from a target dose–volume histogram (DVH), EXCEPT:

A. maximum target dose
B. minimum target dose
C. dose to the hottest 90% of the target
D. volume receiving 90% of the prescribed dose
E. location of the target hotspot

T93. Daily online adaptive radiotherapy allows for reduction in the margins used to generate which of the following structures?

A. GTV
B. CTV
C. ITV
D. PTV
E. MTV

T94. International Commision on Radiation Units and Measurements (ICRU) 83 recommends that _____ should be included in IMRT dose reporting for PTV metrics as it is considered to correspond best with the previously defined dose at the ICRU reference point.

A. D_{max}
B. D_{min}
C. $D_{95\%}$
D. median dose
E. mean dose

T95. Given physical dose (D), biologically effective dose (BED), and equivalent dose in 2 Gy fractions (EQD2), which parameter is always the greatest for the same combination of total dose, dose per fraction, and α/β ratio?

A. D
B. BED
C. EQD2
D. all have the same value
E. not enough information to answer the question

T96. What is a significant limitation of current optical surface guidance technology?

A. incompatibility with DICOM format
B. frame rates are not sufficient to capture respiratory motion
C. difficulty accurately tracking darker skin tones
D. incompatibility with bore-based linear accelerator systems
E. inability to use in the presence of bolus material

T97. According to the AAPM Task Group 302 report on surface-guided radiotherapy, what is the typical positioning accuracy of a surface-guided radiotherapy (SGRT) system?

A. 0.25 mm
B. 1 mm
C. 3 mm
D. 5 mm
E. 10 mm

T98. All of the following can be visualized on a planar kV radiograph to verify the correct positioning for a patient receiving prostate image-guided radiotherapy, EXCEPT:

A. pelvic bones
B. femoral head and neck
C. fiducial markers
D. prostate
E. all of the above can be visualized

T99. A pretreatment free-breathing CBCT acquired on a C-arm linac for a lung patient setup will align most appropriately with which reconstruction from the planning scan?

A. inhale phase of the 4DCT
B. exhale phase of the 4DCT
C. the average image from 4DCT
D. the MIP image
E. the MinIP image

T100. All of the following technologies can be used for motion monitoring during beam-on, EXCEPT:

A. optical surface imaging
B. infrared (IR) marker tracking
C. CBCT
D. MRI cine
E. kV-triggered imaging on fiducial markers

T101. In the process of IMRT inverse planning, _____for a given number of beams are adjusted to _____ the value of a cost function.

A. beamlet weights; minimize
B. dose; minimize
C. beamlet weights; maximize
D. dose; maximize
E. beam energy; minimize

T102. Which of the following is incompatible with an IMRT treatment plan?

A. wedge
B. bolus
C. breath hold
D. pacemaker
E. multiple treatment fields

T103. Which of the following is true for IMRT head and neck plans when compared to IMRT prostate plans?

A. the modulation factor (total MU / Rx dose) is typically lower
B. the average MLC leaf gap is typically larger
C. inhomogeneity corrections are routinely applied for head and neck but not prostate
D. intrafractional organ motion is a larger concern
E. weight loss over the course of treatment is a larger concern

T104. The gamma index method for IMRT QA uses _____ and _____ criteria to evaluate the difference in the dose distribution between planned and measured doses on a point-to-point basis.

A. dose difference and isocenter difference
B. dose difference and conformity difference
C. dose difference and distance to agreement
D. distance to agreement and conformity difference
E. distance to agreement and isocenter difference

T105. What is the primary difference between dynamic conformal arc (DCA) and volumetrically modulated arc therapy (VMAT)?

A. beam energy
B. radiation type
C. modulated dose rate
D. MLC blocking
E. use of cones

T106. In a fixed-gantry IMRT optimization, for the same target and organ-at-risk (OAR) objectives, what will happen to the monitor units as the fluence smoothing priority is increased?

A. increase
B. decrease
C. remain the same
D. not enough information to answer the question

T107. What is the disadvantage of using zero-degree collimator angles in a VMAT plan?

A. decreased leaf speed
B. decreased dose rate
C. increased treatment time
D. increased dose banding
E. increased neutron dose

T108. Why are boost treatments often required in total skin electron treatment using the Stanford technique?

A. the low energy of the electron beam prevents some areas from getting adequately treated at depth
B. the standing positions fail to provide adequate coverage to areas such as the scalp and soles of the feet
C. the consequence of tilting the gantry to avoid excess bremsstrahlung contamination is a gap in coverage at the patient's midsection
D. lung blocks spare the patient's lungs but produce a cold spot that must be covered through a boost
E. the increased SSD reduces the dose rate to a point where repopulation can occur

T109. What is the purpose of the spoiler used during total body irradiation (TBI)?

A. increase the surface dose to the patient
B. lower the dose rate
C. spread out the beam to cover the entirety of the patient
D. reduce the lung dose
E. reduce the variation in TMR across the patient

T110. What is an advantage of AP/PA setup over bilateral setup for total body irradiation (TBI)?

A. no need for a beam spoiler
B. treatment at standard 100 cm SSD can occur for all patients
C. superior dose homogeneity
D. patient comfort for weak or unstable patients
E. no need for lung or brain blocks

T111. Ultra-high dose rate radiotherapy, known as FLASH, refers to dose rates in excess of:

A. 0.004 Gy/s
B. 0.04 Gy/s
C. 0.4 Gy/s
D. 4 Gy/s
E. 40 Gy/s

T112. Which of the following is an advantage of MR-linacs over conventional linacs?

A. produce more conformal treatment plans
B. have MLC tracking capabilities that permit real-time adaptation to account for tumor motion
C. make radiotherapy treatments available for patients with metallic implants that are contraindicated for x-ray-guided radiotherapy
D. can visualize daily changes in anatomy that are not easily visualized with x-ray cone-beam CT guidance
E. the magnetic field interacts with tumor oxygen molecules, increasing biological effective doses (BED) without increasing physical doses

T113. All of the following sources are generated in a nuclear reactor, EXCEPT:

A. Co-60
B. Sr-90
C. Ir-192
D. Cs-137
E. Tc-99m

T114. According to AAPM Task Group 142, what overall delivery accuracy in the coverage of the intended target volume is the standard for SRS procedures?

A. 0.5 mm
B. 1.0 mm
C. 1.5 mm
D. 2.0 mm
E. 2.5 mm

T115. According to AAPM Task Group 101, what is critical to reduce normal tissue toxicity in the delivery of stereotactic body radiotherapy (SBRT)?

A. rapid dose fall-off outside the PTV
B. high dose rate
C. high-energy MV photon beams
D. multiple isocenters
E. physician's physical presence at the delivery machine from the initiation of treatment fraction until its completion

T116. Why do SRS/SBRT targets typically have smaller PTV margins than 3D CRT targets?

A. lower beam energies
B. smaller GTV sizes
C. increased immobilization requirements
D. reduced utilization of multimodality imaging for target definition
E. reduced utilization of intrafraction motion monitoring

T117. According to AAPM Task Group 155, when is a megavoltage photon radiation field defined as "small"?

A. lateral charged particle equilibrium exists on the beam's central axis
B. beam collimating devices partially occlude the primary photon source in the beam axis
C. detector size is smaller than the beam dimensions
D. any field sizes smaller than the standard reference output conditions of the linac
E. MLC sweeps across the field while the beam is on

T118. According to the AAPM-RSS (Radiosurgery Society) Medical Physics Practice Guideline 9a on SRS-SBRT, what is the tolerance for the difference between the measured versus calculated dose when performing an annual end-to-end dosimetric evaluation of a SRS/SBRT C-arm linac delivery system?

A. 0.5%
B. 1%
C. 2%
D. 3%
E. 5%

T119. According to the NRC, a patient who received a permanent brachytherapy implant may be released from the hospital if the total effective dose equivalent to any other individual from exposure to the released individual is not likely to exceed what maximum amount?

A. 0.1 mSv
B. 0.5 mSv
C. 1 mSv
D. 5 mSv
E. 10 mSv

T120. According to the Nuclear Regulatory Commission (NRC) 10 CFR 35, what is one of the five necessary components of an authorized user's written directive for HDR brachytherapy procedures using a remote afterloader?

A. immobilization technique
B. target coordinates
C. route of administration
D. radionuclide
E. patient exposure rate for release from the hospital

T121. What quantity is currently recommended by the AAPM for the specification of brachytherapy source strength?

A. activity
B. equivalent mass of radium
C. exposure rate at a specified distance
D. air kerma strength
E. absorbed dose to water at a specified distance

T122. Both isotope A and isotope B can be used for the same permanent implants. If the half-life of isotope A is three times the half-life of isotope B ($T_{1/2,\,A} = 3\ T_{1/2,\,B}$), the initial dose rate of isotope B needs to be how many times the initial dose rate of isotope A to cumulate the same permanent implant dose?

A. 1/4.32
B. 1/3
C. 1/2
D. 3
E. 4.32

T123. The treatment time for a HDR brachytherapy plan with an Ir-192 source was 250 seconds using a nominal source strength of 10 Curie (Ci). The source strength at the time of treatment was 7.5 Ci. How long is the treatment?

A. 188 s
B. 250 s
C. 333 s
D. 418 s
E. 500 s

T124. All of the following are used in a prostate seed implant nomogram to determine the approximate number of seeds required, EXCEPT:

A. prostate volume
B. prescription dose
C. seed strength
D. seed isotope
E. dose limits for rectum and urethra

T125. What is the primary mode of decay for iodine-125?

A. alpha decay
B. positron decay
C. electron capture
D. negatron decay
E. Compton scatter

T126. If the total prescribed dose is kept constant, which of the following combinations results in the largest amount of transit dose for a HDR treatment course?

A. 10 Ci source, three fractions
B. 5 Ci source, three fractions
C. 10 Ci source, five fractions
D. 5 Ci source, five fractions
E. the transit dose does not depend on the source strength or number of fractions

T127. According to ICRU 38, HDR is defined by prescription dose rates above what value?

A. 0.4 Gy/hr
B. 2 Gy/hr
C. 4 Gy/hr
D. 12 Gy/hr
E. 20 Gy/hr

T128. Which of the following statements regarding HDR brachytherapy QA is true?

A. farmer-type ionization chambers are used for source strength measurements
B. source strength measurements should agree within ±5% with a secondary check
C. the positional accuracy for HDR brachytherapy is ±3 mm
D. checks of afterloader interlocks should be performed monthly
E. checks of afterloader emergency retraction should be performed monthly

T129. How will increasing the applicator diameter affect the dose at the applicator surface for the same dose to the prescription depth?

A. increase
B. decrease
C. remain the same
D. not enough information to answer the question

T130. Prescribing to the 3D target volume for tandem and ovoid brachytherapy mitigates what issue with historical treatment prescriptions?

A. prescribing to point A does not account for anatomical variations between patients
B. prescribing to point B does not account for anatomical variations between patients
C. organ-at-risk sparing was impossible in the absence of 3D target and organ-at-risk definition
D. need to use packing to push the rectum and bladder away from the applicator

T131. The American Brachytherapy Society defines the location of point A in cervical cancer brachytherapy in the following manner: On the treatment planning computer, first connect a line through the center of each ovoid. From the point on the tandem where this line intersects, extend superiorly the radius of the ovoids and then move ____ cm along the tandem. Point A is then _____ cm laterally on a perpendicular line from this point on the tandem.

A. 1; 2
B. 2; 1
C. 2; 2
D. 2; 5
E. 5; 2

T132. The air kerma rate at 2 meters from a brachy source is 0.5 μGy h^{-1}. What is the source strength of this source?

A. 0.25 U
B. 0.5 U
C. 1 U
D. 2 U
E. 4 U

T133. AAPM Task Group 43–based brachytherapy dose calculations include all of the following considerations, EXCEPT:

A. spatial distribution of activity within the source
B. photon absorption in the medium
C. photon scattering in the medium
D. filtration of photons traveling through the source encapsulation
E. tissue heterogeneity

T134. Uncertainties in the conversion of CT number to stopping power contributes to which type of uncertainty in proton therapy?

A. energy uncertainty
B. dose rate uncertainty
C. setup uncertainty
D. range uncertainty
E. isocenter localization uncertainty

T135. Compared to proton therapy, carbon ion therapy:

A. is less expensive
B. is more widely available
C. permits the use of smaller treatment machines
D. has a sharper beam penumbra
E. has a better understood radiobiological response

T136. Which of the following is an advantage of proton-based craniospinal irradiation (CSI) treatment over intensity-modulated photon-based CSI?

A. reduced high dose to nontarget structures
B. reduced low dose volume to the entire body
C. better PTV coverage
D. no need to feather
E. time efficient

T137. Where is the relative biological effectiveness the greatest along the depth dose curve for a therapeutic proton beam?

A. entrance surface of the medium
B. proximal side of the spread-out Bragg Peak
C. in the center of the spread-out Bragg Peak
D. distal side of the spread-out Bragg Peak
E. stopping power is constant throughout

T138. What is the benefit of pencil beam scanning over passive scattering in proton radiotherapy?

A. increased dose conformality around the target on the distal side
B. increased dose conformality around the target on the proximal side
C. decreased sensitivity to patient motion
D. decreased sensitivity to CT number to stopping power conversion
E. decreased range uncertainty

T139. What is an advantage of failure modes and effects analysis (FMEA) over root-cause analysis (RCA) in risk mitigation?

A. FMEA utilizes precise, evidence-based, quantitation of event severity to calculate risk
B. RCA always focuses on individual performance, whereas FMEA focuses on system improvements
C. FMEA is prospective risk analysis, whereas RCA is reactive post-failure analysis
D. FMEA can be performed very quickly after an event, whereas RCA requires a lengthy investigation
E. RCA requires input from many team members estimating risk potential and FMEA can be performed by a single individual

T140. The NRC would need to be notified no later than how long after a medical event is discovered?

A. 1 day
B. 7 days
C. 15 days
D. 30 days
E. 60 days