

(Model Answer)

I. Answer the following by selecting ONE answer from the choices:

1. For an image intensifier to obtain the maximum detection quantum efficiency (DQE),
 - a. Input metal window must give minimal transmission
 - b. Input phosphor must offer minimum absorption
 - c. Maximum light conversion and highest SNR for imaging chain (sol=T)
2. Fluoroscopy uses a low input dose rate of about(sol= $0.2 \mu\text{Gy s}^{-1}$) but during cut film or cone this dose must be increased to about(sol= $0.9 \mu\text{Gy}$) per frame for correct film exposure. (Page 245)
 - a. 0.1 , 0.5
 - b. 0.2, 0.9
 - c. 0.3, 1.3
3. Spatial filtering techniques can be used to emphasize features of different(sol=sizes)
 - a. Sizes
 - b. Colors
 - c. shapes
4. Low-pass filters (smoothing) in image processing are used to reduce (sol=noise)
 - a. Acquisition time
 - b. Noise
 - c. fogging
5. High-pass filters are used to enhance (sol= edges or contrast) in an image.
 - a. Contrast
 - b. Noise
 - c. Resolution
6. In nuclear medicine, increasing the pixel count can be achieved by increasing (sol=radiation) or (sol=time) per study or by adding successive images.
 - a. Radiation, Time
 - b. keV, mAs
 - c. TR, TE
7. At high kVs (about 80 kV), the film density doubles for every (sol=15 kV)
 - a. 5 kV
 - b. 10 kV
 - c. 15 kV
8. At high kV in a chest radiograph, the exposure time typically can be reduced to (sol= 20 ms)
 - a. 20 ms
 - b. 200 ms
 - c. 2 s
9. The dynamic range of an image intensifier covers several orders of magnitude. The lower limit is due to (sol=dark current) of the photocathode, the upper limit is due to the(sol=induced current within photocathode) (page 235)
 - a. keV, mAs
 - b. Atomic number (Z), Tube current
 - c. Dark current, Induced current within photocathode

10. Output phosphor low contrast visibility is optimum between 0.15 and 1 $\mu\text{Gy s}^{-1}$ where (sol=resolution) approaches maximum. (page235)
- Resolution
 - SNR
 - Noise
11. At low kVs and small focal spots, tube current is space charge limited. This can be improved by (sol=increasing) filament area and (sol=decreasing) the cathode anode distance.
- Increasing, Increasing
 - Increasing, Decreasing
 - Decreasing, Increasing
12. Surveys of mean glandular dose in mammography (MGD) using current equipment now give recommendation that values should not exceed (sol=1.3mGy) (page 220)
- 1.3 mGy
 - 5 mGy
 - 6.2 mGy
13. To have a constant image density in mammography for increasing breast thickness (sol=AEC) should be used.
- Nouniform filtering
 - AEC
 - MGD
14. Modulation transfer function for a perfect imaging system is given as MTF of (sol=1)
- 1
 - 0.1
 - 0
15. The limit of visual detail is normally taken at an MTF of (sol=10%)
- 1%
 - 10%
 - 100%
16. Contrast detail diagram indicates the threshold contrast needed to detect an object as a function of its (sol=diameter)
- Diameter
 - Thickness
 - Resolution
17. Conventional radiographic film can resolve $\text{Lp}\cdot\text{mm}^{-1}$ (sol= 5-8)
- 1-5
 - 5-8
 - 10-15
18. Mammography radiographic film can resolve $\text{Lp}\cdot\text{mm}^{-1}$ (sol=10-15)
- 1-5
 - 5-8
 - 10-15
19. In order to have high definition radiology displays, we use scan lines in order to give film-like image quality (sol=3000)
- 1000
 - 3000
 - 10000

20. FFD in mammography is 60 cm and the focal spot is 0.4 mm. The center of the breast is 3 cm from the film plane. The geometric unsharpness is (sol= 0.02 mm) (page 216)
- 0.02 mm
 - 0.2 mm
 - 2 mm
21. For x-ray photon energy of 60 keV and for Lanthanum oxy-bromide screen emitting two peaks at 360 nm and 475 nm with approximately 20% efficiency, the light output is equal to photons (sol= 4000).
- 1000
 - 2000
 - 4000
22. Screen asymmetry is an advantage for high kV (fluoroscopy and chest imaging) if we use a (sol= medium thickness) front screen and (sol= maximum thickness) rear screen.
- Medium thickness , Maximum thickness
 - Maximum thickness , Minimum thickness
 - Maximum thickness, Medium thickness
23. The sensitometer is a stable light source illuminating an optical (sol= step wedge)
- Window
 - Step wedge
 - Meter
24. X-ray film alone absorbs about 1-2% of the incident beam while intensifying screens using elements of atomic number Z from 57-74 are effective absorbers of x-ray radiation of about (sol=30-50%)
- 1-10%
 - 10-30%
 - 30-50%
25. Sodium Iodide is the scintillator of choice owing to its high (sol=quantum) efficiency and its light output is in the (sol= ultraviolet) spectrum. (page 141)
- Quantum , Ultraviolet
 - Scintillation, Visible
 - Conduction, infrared
26. Hyper-pure germanium detectors show energy resolutions typically less than (sol=1%) at 1 keV. (page 142)
- 0.1%
 - 1%
 - 10%
27. Film emulsion consists of in gelatin. (sol=AgBr + AgI)
- AgBr
 - AgI
 - AgBr+AgI
28. Film fixing removes unexposed silver halide as complex (sol=soluble)
- Soluble
 - Solid
 - Usable
29. LET for photons ranges from (sol= 0.2-3) keV μm^{-1} (page 127)
- 0.1-0.2

- b. 0.2-0.3
 - c. 0.3-0.4
30. The Xenon gas ion chamber found as CT machine detectors has an efficiency of ...% (sol=50-60% - put options 60-70 and 70-80) (page 131)
- a. 50-60
 - b. 60-70
 - c. 70-80
31. Proportional chambers are found as radiation monitors (sol=large area) (page 132)
- a. Local area
 - b. Large area
 - c. Limited area
32. Lubricant of anode bearing is usually (sol= metallic gallium)
- a. Metallic gallium
 - b. Metallic germanium
 - c. Metallic gadolinium
33. Series loadability is proportional to the diameter of the (sol=focal track)(page 84)
- a. Anode rotor
 - b. Focal track
 - c. Cathode filament
34. Variation of the power output for DSA and mammography should be between (sol=1-2%) and is less than (sol= 1%) for CT imaging.
- a. 1-2% , 1%
 - b. 0.1-0.2%, 0.1%
 - c. 0.01-0.02%, 0.01%
35. A common filter material for CT imaging (120-140 kVp) is (sol=Cu+Al)
- a. Cu+Al
 - b. Ni
 - c. Pb
36. Mammographic tubes are designed for kVp while tubes for CT are designed for kVp. (sol= 20-30 and 140)
- a. 40-50, 100
 - b. 30-40, 120
 - c. 20-30, 140
37. For very short exposure times of 0.1s or less, short term loadability is determined by the (sol= size) of the anode target while long term loadability is determined by anode (sol=cooling).
- a. Size, Cooling
 - b. Material, Heat conduction
 - c. Rotation, Current
38. Metal/ceramic tubes can have a heating storage approaching HU and a continuous load of W (sol= 5M HU, 7 kW) (page 87)
- a. 5k, 10k
 - b. 5M, 7k
 - c. 10M, 20k
39. The x-ray tube and generator housing are separate at power ratings higher than (sol= 50 keV)
- a. 50 keV
 - b. 100 keV

- c. 120 keV
40. Increasing the anode angle (sol= decreases) the focal spot area, which (sol=reduces) anode rating.
- Increases , Increases
 - Decreases, Reduces
 - Increases, Reduces
41. The heel effect (sol= decreases) with increasing anode angle.
- Decreases
 - Increases
 - Does not change
42. An acceptable leakage figure for current x-ray equipment would be \leq (sol=0.5) mSv h⁻¹ at 150 kVp. (page 75)
- 0.5
 - 1
 - 2
43. The effective energy of a moderately filtered x-ray spectrum is roughly kVp (sol=2/3) (page 77)
- 1/3
 - 1/2
 - 2/3
44. In order to achieve the same film density when increasing 50 kV to 60 kV, then the exposure time should be altered by a factor of (sol= (50/60)⁴ = 0.5)
- 1.2
 - 0.5
 - 2
45. Germanium makes a more efficient x-ray detector than silicon because Germanium has a higher (sol= atomic number Z)
- Conductivity
 - Isolation
 - Atomic number (Z)
46. X-ray filament is made of (sol=tungsten) wire, with low voltage AC of about (sol= 8-12) volts.
- Tungsten, 8-12
 - Copper, 24
 - Stainless steel, 48
47. The level of (sol= filament) current significantly determines the life time of the x-ray tube.
- Tube
 - Filament
 - Anode
48. A fine focus x-ray beam is typically (sol=0.1-0.4) mm wide.
- 0.01-0.05
 - 0.05-0.1
 - 0.1-0.4
49. In a 100 mm diameter anode with 7mm track width, anode rotation speed 9000 rpm, the complete target area is exposed every (sol= 0.0066) sec.
- 0.0066
 - 0.66

- c. 4.62
50. The measured value from a radiation dose meter is 8.800. How many significant digits are there ?
 (sol=4)
- 1
 - 2
 - 4
51. The periodic table has (sol=92) naturally occurring elements.
- 92
 - 122
 - 132
52. The atomic mass unit is (sol= 1/12) of a carbon atom.
- 1/2
 - 1/6
 - 1/12
53. A full-wave rectified, three-phase, six-pulse waveform produces approximately (sol=35%) more average photon energy than full-wave rectified single phase.
- 300%
 - 100%
 - 35%
54. The maximum energy imported to a Compton electron when the electron is scattered at (Sol=180) degrees to the incident photon.
- 0
 - 90
 - 180
55. In a perfect detection system, a mono-energetic gamma source such as Cs-137 should yield a single fine photo peak at (sol=662) keV.
- 128
 - 662
 - 842
56. The efficiency for a 10 mm² detector at 25 mm is % . (sol= 0.12%)
- 0.12
 - 12
 - 40
57. Oxygen has an electron density of 3.01×10^{23} , hydrogen has an electron density of (sol= 6.02×10^{23})
- 1.5×10^{23}
 - 6.02×10^{23}
 - 18.06×10^{23}
58. Heavy-duty x-ray tube anodes are protected from nonuniform expansion by placing (sol= stress cuts) along their circumference.
- Stress cuts
 - Protective enclosures
 - Support frames
59. Molybdenum is used as the anode stem because of its (sol=poor) heat conduction.
- Good
 - Poor

- c. stable
60. A continuous x-ray spectrum from 60-120 keV has a wavelength range from (sol= 0.02-0.0099) nm.
- a. 0.02-0.0099
 - b. 0.01-0.0199
 - c. 0.001-0.00099
61. Light rays in glass are totally reflected if their angle of incidence is increased beyond a critical angle of degree. (sol= 42)
- a. 30
 - b. 42
 - c. 90
62. The size of a circular transducer of 15 mm is approximately 20λ at 2 MHz and is about..... (sol= $48 - 50 \lambda$) at 5 MHz.
- a. 8
 - b. 48
 - c. 72
63. With apodization, the width of the main lobe (sol= increases) and the amplitude of the side lobes (sol=decreases).
- a. Increases , Decreases
 - b. Decreases, Increases
 - c. Increases, Increases
64. The pressure reflection coefficient at the muscle/blood interface is (sol= +/- 0.02)
- a. 0.001
 - b. 0.01
 - c. 0.02
65. For a depth of 16 cm and 128 beams per image, we are able to obtain frames per second. (sol= $30 - 37$??).
- a. 20
 - b. 25
 - c. more than 30
66. An aortic aneurysm shows internal cavity noise. To reduce the cavity noise a linear transfer curve is not used but rather is used. (sol=reduced gain for low level signals)
- a. Higher gain for low level signals
 - b. Reduced gain for low level signals
 - c. Reduced gain for high level signals
67. To get wider image field than in linear array, array is used. (sol=curvilinear or convex).
- a. Curvilinear
 - b. Endocavity
 - c. Concave
68. The advantage of an annular array is that the focus is (sol= symmetric).
- a. Accurate
 - b. Symmetric
 - c. Static
69. The sweeping of the focus during receive is called (sol= dynamic focus)
- a. Scanning
 - b. Dynamic focus

- c. Static focus
70. The total dynamic range of ultrasound in tissues is typically (sol=100-120) dB.
- 50-60
 - 60-100
 - 100-120
71. The local dynamic range is determined by the ratio of the main lobe to the side lobe level, which is about (sol=50-60) dB.
- 50-60
 - 60-100
 - 100-120
72. We use lower ultrasound frequencies in Doppler measurements so that we can improve (sol=sensitivity), and reduce (sol= aliasing) in PW Doppler.
- Resolution , Noise
 - Sensitivity , Aliasing
 - Frequency shift, Scan time

II. Compute the answers to the following problems – Make sure to show your work

73. For a 40 cm image intensifier and a 1023 line display, What would be the resolution in lp/mm ? (sol=1.8 lp/mm)
74. For a laser image scanning 14×17 inch film producing an area of 4096×5120 pixels then it will accommodate (sol=20) MRI images of 1024×1024 pixels each.
75. In laser image scanning of 14×17 inch film producing an area of 4096×5120 pixels, each line of pixels is exposed in approximately 3.8 ms. So the time required to expose the complete film area is about (sol= 20) seconds.
76. In mammography where $E_{\text{eff}}=20$ keV, tissue thickness = 5 cm, and $\mu=0.7613$ cm⁻¹, the dynamic range is equal to (sol= $1/\exp(-0.7613*5)= 45:1$).
77. Grid parameters strip thickness $d=0.07$ mm, interspace material thickness $D=0.18$ mm, grid height $h=1.4$ mm, compute the grid ratio, line density (lines/cm), and transmission (sol=7.7, 40, 72%) (page 193)
78. Using a 9600 baud telephone line transmitting a CT image of 512×512×12 bits, the transmission time is (sol= 5.46 min NOT 3.6 min) and for a fiber optic cable transmitting at 1 G bits/s, the transmission time is (sol= 3.14 ms NOT 0.05 s) (page 267).
79. In fluoroscopy system, 3×10^5 photons/mm² giving a skin dose of 10 mGy, the quantum noise is given by (sol= 0.18%) (page 234)
80. In nuclear medicine having a total count of 10^6 photons on a 128×128 matrix the quantum noise per pixel is (sol=12.8%)
81. In a phosphor imaging plate, if the response time of the photo-stimulated luminescence (PSL) is 0.8 μ s, then a 5000×4000 pixel matrix will take (sol=16 s ?)
82. The mass absorption coefficient (μ/ρ) for soft tissue at 60 keV is 3.06×10^{-3} while that for bone is 9.988×10^{-3} and for air is 3.004×10^{-3} . Compute the f-factor for bone in grays (sol=112.54) (page 126)
83. The number of x-ray photons produced during a standard chest radiograph of 60 kV and 5 mAs is (sol= 1.5×10^{14}) photons. If the area is 1500 cm², the energy fluence ψ is (sol= 6×10^9) MeV cm⁻².
84. 1 Roentgen produces a total ion charge of (sol= 2.58×10^{-4}) coulomb/kg thus creating (sol= 2.08×10^9) ion pairs per cubic centimeter.

85. How many heat units are generated by two exposures of 65 kVp, 400 mA and 0.05 sec on a 3 phase 12-pulse unit? (sol= $65 \times 400 \times 0.05 \times 1.41^2 = 3.666$ HU)
86. The original activity of iodine 131 (half life $t_{1/2} = 8$ days) on day 0 was 400 MBq in 2 cm³ saline. On day 5, 130 MBq is required. What volume must be drawn up? (sol= 1 cm³).
87. If in counting radioactivity a crystal is 4 cm in diameter and is situated 10 cm from the source, the exposed area is only % (sol=1%).
88. A 10-minute determination of a sample yields 5480 counts. The background is 140 counts in 5 minutes. This yields a net count of (sol= $5480/10 - 140/5 = 520$) cpm and a standard deviation for net of (sol= $\sqrt{520} = 22.8$) cpm.
89. In a radiology department with 20% rejection rate for its film radiographs, a group of 5 films was selected at the end of each clinical session, 12 sessions per day. At the end of the year, (sol= 4380) groups of 5 films had been analyzed. The binomial distribution for the different outcomes can be written as: (sol= $(0.2)^5 + 5 (0.2)^4 (0.8) + 10 (0.2)^3 (0.8)^2 + \dots$)
90. 1eV = J. (sol= 1.6×10^{-19})
91. 7.5 mGy h⁻¹ will give $\mu\text{C Kg}^{-1} \text{ hr}^{-1}$ (sol= 0.22) (page 132)
92. Binding energy for tungsten k-shell is 69.5 keV, L-shell is 12 keV, and M-shell is 1.8 keV. Total energy of characteristic radiation is (sol=69.5 keV) while the Auger electron energy is (sol=45.5 keV) (page 116)
93. The temperature rise in 1 cm³ water for a 10 Gy exposure is °C (sol= 0.002386) (page 125)

III. Write down the equations / terms required in the following questions:

94. The efficiency of an image intensifier is measured as (sol= output phosphor luminance / input phosphor dose)
95. Selectivity of a grid Σ is defined as: (sol= ratio of transmitted primary / transmitted scatter)
96. The variation in mAs value ΔQ given by a high frequency generator depends on tube current I and switching frequency F as: (sol= $dQ = I/2F$)
97. In high frequency transformers, cross section A and number of turns N are related to the output voltage V and frequency F as (sol= $V = A \times N \times F$)
98. Film screen artifacts include (1)..... (2)..... (3)..... (sol= print-through, halation, and separation) (page 166)
99. The thermo-luminescent material is commonly barium fluorohalide of the type BaFX:Eu²⁺ where X is the halide atom, or (sol= Cl, Br or I) (page 142)
100. The Compton edge is determined by the relation (keV)= (sol= $E^2/(E+256)$??) (page 120)
101. The backscatter peak (keV) can be calculated as (keV) = (sol= $256 E/(E+256)$)
102. Subject contrast is affected by (1)....., (2)....., (3)....., and (4)..... (sol= kV, μ , tissue thickness, tissue density, Z, and beam filtration) (page 187)
103. Subjective contrast is affected by (1)....., (2)....., (3)..... (sol= film viewer, light color, magnification, masking) (page 188)
104. Recommendations to extend x-ray tube life: (1)..... (2).....(3)..... (sol= (1) use lower mA when possible (2) use lower speed rotor when possible (3) do not make repeated exposures near tube loading limits)
105. Factors affecting dose-area product are: (1) (2) (3)..... (4)..... (5)..... (sol= (1) kVp (2) mA (3) mm Al (4) time (5) Area)
106. The sound velocity is related to the density ρ and the bulk compressibility K of a material as : $c =$ (sol= $1/\sqrt{\rho K}$)

107. In an A-mode ultrasound system, if the length of the transmitted pulse is T_p , the range resolution is (sol= $cT_p/2$)
108. In a phased linear array to have adequate energy at an angle of 45 degrees, the width of the element should be \leq (sol= $\lambda/2$), and the centers of the neighboring elements must be less than (sol= $\lambda/2$). To get an adequate aperture, typically (64-128) elements are necessary and the width of the transducer is in the range of λ (sol=32-64). At 5MHz, this is 10-20 mm.
109. If we want to steer the beam of a phased array at an angle θ , the width of the transducer is D , the maximum delay required is $T_m =$ (sol= $D \sin\theta / c$)

IV. Answer The following questions with either True (T) of False (F):

110. Properties of video cameras: for a CCD camera, the resolution is better than for vidicon and plumbicon (sol=T?) (page 240)
111. The focal spot size in an image intensifier is a limiting factor for image resolution (F)
112. Cine fluorography normally employs a double imaging system for the heart (sol=T) (page 243)
113. The under-table x-ray tube of a fluoroscopy system has a better resolution than on over-table x-ray tube (sol=F) (page 248)
114. In a C-arm mobile unit, the SID may be 90 cm (sol=T) (page 249)
115. WORM is a storage media that is suitable for radiology archives (sol=T) (page 263)
116. DICOM standard is the standard data transmission protocol for clinical data and images set up by the ACR and NEMA (Sol=T) (page 271)
117. Adaptive unsharp masking (AUSM) is used for effective and rapid edge enhancement of CT images. (sol=T)
118. The size of the focal spot in high kV imaging can be larger since FFD can be 70-200 cm (sol=T)
119. As x-ray energy (keV) increases, subject contrast becomes more independent off electron density. (sol=F)
120. Cine-angiography requires batch loadability (sol=F)
121. Ice, liquid water and vapor have the same mass attenuation (sol=T)
122. In mammography a single thick screen is used (sol=F)
123. Increasing screen speed above 200 will preserve diagnostic details (sol=F)
124. Most regulations require that the solver recovery effluent for discharge to the public sewer should be less than 0.5g solver per liter (sol=F)
125. Lanthanum and Gadolinium light spectra compared to CaWO_4 shows peaks rather than a broad wavelength spectrum (sol=T)
126. GM counters are never used as radiation leakage detectors (sol=F) (page 134)
127. Mixed grain size of film emulsion has greater contrast (sol=F)
128. A CT anode is never made flat (sol=F)
129. X-ray tubes with sleeve bearings are kept running throughout the work day (sol=T)
130. In soft tissues, shear waves are not attenuated (sol= F)
131. Ultrasound velocity in bone is fixed and equals 4100 m/s (sol= F)
132. By using an absorbing backing on a transducer plate, the sensitivity of the transducer as a receiver is reduced. (sol= T)
133. Near field is better with linear than curvilinear transducers (sol=F)
134. In measuring portal venous velocities, a high-pass filter is used. (sol= F)
135. In a dual transducer annular array probe, the tissue element and the Doppler element should coincide. (sol=F)

(The rest of answers will be posted later)