BioE 1330 - Review Intro and Chapters 1, 2, and 3 9/27/2018

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

_____

your signature

1. Which of the following imaging modalities do not use ionizing radiation? (pick best answer)

A. Only CT

B. Ultrasound and CT

C. Only ultrasound

D. Only MRI

E. Ultrasound and MRI

2. The mid-sagittal plane

A. represents a projection through the side of the body.

B. divides the body into two roughly symmetrical halves.

C. is only used in CT but not MRI.

D. is parallel to the top of the head.

E. is parallel to the front of the body.

3. The sagittal plane

A. represents a projection through the side of the body.

B. is parallel to the front of the body.

C. is used only in projection radiography.

D. is parallel to the top of the head.

E. is perpendicular to the coronal plane.

4. The following is <u>not</u> true about the impulse function, $\delta(x)$.

A. It has an area of 1.

B. It is also known as the Dirac function.

C. $\delta(0) = \infty$.

D. It cannot be integrated.

E. It is infinitely narrow.

5. Computerized Tomography (CT)

A. requires extremely strong magnetic fields.

B. requires the use of radioactive isotopes.

C. depends on multiple projections of X-rays from many angular orientations to compute a slice of voxels.

D. is primarily used to image physiological function rather than anatomical structure.

E. cannot be used to produce a 3D set of voxels.

6. The following is true of the Gaussian function, generally of the form $\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. Convolution with another Gaussian always yields a Gaussian whose standard deviation σ is at least as large as the larger of the two constituent's σ.

B. It represents a cosine in the real domain and a sine in the imaginary domain.

C. Multiplication with another Gaussian having the same mean μ yields a Gaussian with the same mean.

D. It approaches an impulse function when σ approaches 0.

E. When $\mu = 0$, the Gaussian is an even function.

7. The following is true of convolution, *except*

A. It exhibits the property of commutativity.

B. Convolution in the temporal (or spatial) domain is equivalent to multiplication in the frequency domain.

C. It exhibits the property of associativity.

D. Convolution with a Gaussian applied to any function $f(x)$ yields the same function $f(x)$.

E. It can be used on signals in both the temporal and spatial domains.

8. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*

A. It represents a cosine in the real domain and a sine in the imaginary domain.

B. It is a periodic function.

C. Complex conjugate pairs of these complex exponentials form real sinusoidal variations at particular orientations and frequency in space.

D. It forms an orthogonal basis set from which any image can be constructed.

E. It has an imaginary component, making it incapable of being used in the construction of real images.

9. Which of the following statements is true about the Bessel function?

I - They are a family of functions, specified by kind and order.
II - They exhibit circular symmetry and can represent waves passing through an aperture.
III - Convolution of a function $f(x, y)$ with a Bessel function yields a Rect function.

A. I.

B. I, II, and III.

C. II and III.

D. I and II.

E. I and III.

10. Which of the following statements *best* summarizes why a sampled function in the spatial domain is periodic in the frequency domain.

A. Convolution with a Step function is equivalent to integration.

B. An impulse function in the discrete domain has an amplitude of 1.

C. A sampled complex exponential can take an unknown number of complete revolutions in the complex plane between one sample and the next.

D. Positive and negative frequencies represent complex conjugate pairs of complex exponentials.

E. A low pass filter applied before sampling is required if frequencies exist in the continuous domain above the Nyquist frequency.

11. The following are true about the Modulation Function $m_f = \frac{f_{max}-f_{min}}{f_{max}+f_{min}}$ of $f(x, y)$, *except*

A. It equals 1 only when$f_{min} = 0$.

B. It is always in the range $0 \leq m_f \leq 1$.

C. For a sinusoidal variation in intensity, it represents the amplitude of the sinusoid over its average value.

D. It is a measure of the contrast in an image.

E. It equals $\frac{1}{2}$ when there is no contrast in the image.

12. In the continuous domain, the following are true about the probability *density* function.

I - It represents the derivative of the probability *distribution* function (also called the "cumulative distribution function".
II - It has an area of 1.
III - It can never be negative.

A. I, II, and III.

B. None of them is true.

C. I and II.

D. II and III.

E. I and III.

13. The following are true about the Poisson distribution *except*

A. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf)

B. It may represent continuous or discrete random variables.

C. It can model randomly occurring discrete events.

D. Its mean and variance are equal.

E. It is used to represent variation between samples of high-energy photons in an x-ray image.

14. Consider the following continuous systems whose output $g(x, y)$ is related to its input $f(x, y)$ as follows:

I - $g(x, y) = 2f(x, y)$
II - $g(x, y) = xyf(x, y)$

Which system is (are) both linear and shift-invariant?

A. Neither of them
B. I and II
C. II
D. I
E. Cannot be determined

15. Determine which of the following signals are separable.

I rect(x,y)
II sinc(x, y)
III $\delta(x, y)$

A. I and II
B. II
C. I and III
D. I, II, and III
E. I

16. Determine which of the following signals are periodic in both x and y.

I - comb(x,y)
II - $\delta(x, y)$
III- $f(x, y) = \sin(\frac{x+y}{5m}) + \cos(\frac{x+y}{5n})$, for all real numbers $m \neq n$

A. II and III
B. I, II, and III
C. I and II
D. II
E. I

17. Given a continuous signal $f(x, y) = x + y^2$, evaluate the following: $f(x, y)\delta(x - 2, y - 1)$

(Note that the impulse is not being integrated!)

A. $3\delta(x - 2, y - 1)$
B. $x + y^2$
C. 5
D. $(x - 2) + (y - 1)^2$
E. 3

18. For each system with the following PSF, determine which one is stable.

I - $h(x, y) = x^2 + y^2$
II - $h(x, y) = x^2 e^{-y^2}$

A. I and II

B. II

C. Cannot be determined

D. I

E. Neither of them

19. Match following terms with their definitions

a - Contrast
b - Resolution
c - Noise
d - Artifacts
e - Distortion

1 - is any geometric inaccuracy in size or shape.
2 - is any random fluctuation in an image.
3 - is the ability of an imaging system to distinguish neighboring points in space, time, or energy as distinct.
4 - the difference in image intensity of an object or target and surrounding objects or background.
5 - are false signals in an image that do not represent any valid structural or functional signal in the patient.

A. a - 4, b - 3, c - 5, d - 2, e - 1

B. a - 2, b - 5, c - 1, d - 3, e - 4

C. a - 4, b - 3, c - 2, d - 1, e - 5

D. a - 4, b - 3, c - 2, d - 5, e - 1

E. a - 3 , b - 4 , c - 2, d - 5, e - 1

20. Select the statement that best describes the field of Medical Imaging.

A. Requires training in computational and life sciences.

B. Can be used for Diagnosis and Therapy.

C. All of the other statements.

D. Integrates Bioengineering, Biology, and Medicine.

E. Is a multidisciplinary area.

21. Which one of the following statements is true? The two medical imaging techniques, CT (Computed Tomography) and MRI (Magnetic Resonance Imaging), are complimentary because

A. CT differentiates tissues by their attenuation of x-rays while MRI differentiates the local environments of hydrogen nuclei.

B. MRI is a tomographic modality whereas CT is not.

C. CT images bone differently from soft tissue whereas MRI does not.

D. None of the other statements is true.

E. MRI uses ionizing radiation whereas CT does not.

22. Which of the following statements is true?

A. MRI relies on nuclear resonance and CT on emission of radiation by tissue.

B. Ultrasound is the only imaging modality that does not use ionizing radiation.

C. X-rays, CT, and PET are all examples of transmission imaging.

D. None of the other statements is true.

E. PET and MRI are examples of emission imaging.

23. A physical examination was used to screen for breast cancer in 2,500 women with biopsy-proven adenocarcinoma of the breast and in 5,000 age- and race-matched control women without the disease. The results of the physical examination were positive in 1,800 of the women with known adenocarcinoma and in 800 control women who showed no evidence of cancer at biopsy. Find the *sensitivity* of the physical examination

A. 36.0

B. 28.0

C. 84.0

D. 69.2

E. 72.0

24. Which of the following statements about sampling is true?

A. The Nyquist frequency is twice the lowest frequency present in the signal.

B. Sampling explains why we sometimes see movies with cars that appear to have wheels turning backwards.

C. Sampling rate is unrelated to the presence of aliasing in a signal.

D. The Nyquist frequency is one-half of the highest frequency present in the signal.

E. The application of a filter to a continuous signal prior to sampling is needed to eliminate the frequencies lower than the sampling frequency.

25. Which of the following properties of the Fourier Transform is incorrectly shown?

A. Convolution: $F_{2D}(f * g)(u, v) = F(u, v)G(u, v)$

B. Translation/Shifting: $F_{2D}(f(x - x_0, y - y_0))(u, v) = F(u, v)e^{-j2\pi(ux_0+vy_0)}$

C. Parseval's Theorem: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|f(x, y)|dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|F(u, v)|dudv$

D. Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|}F\left(\frac{u}{a}, \frac{v}{b}\right)$

E. Linearity: $F_{2D}(a_1f + a_2g)(u, v) = a_1F(u, v) + a_2G(u, v)$

26. A population of 1000 people is tested for a disease. 800 receive a negative result. The prevalence of the disease is known to be 15%. What is the minimum value for the sensitivity of the test required to make the diagnostic accuracy at least 90%?

A. 0.800

B. 0.833

C. 0.625

D. 0.912

E. 0.850

27. You are visiting the doctor for a checkup. You have a routine test performed, and the result of the test is negative. You ask the doctor what it means to have a negative result: "Given that I have a negative test result, what is the chance that I actually don't have the disease?" Which term describes the value that the doctor is about to give you?

A. Positive predictive value

B. Prevalence

C. Negative predictive value

D. Specificity

E. Diagnostic accuracy

28. The line spread function for a medical imaging system is given as
$l(x) = 4\cos(\alpha x)$ for $|x| \leq \frac{\pi}{20}$ and 0 otherwise. What is the resolution of this modality if $\alpha = 10$ radians/cm?

A. $\frac{3}{\pi}$ cm^{-1}
B. $\frac{30}{\pi}$ cm^{-1}
C. $\frac{\pi}{15}$ cm^{-1}
D. $\frac{\pi}{30}$ cm^{-1}
E. $\frac{15}{\pi}$ cm^{-1}

29. Which of the following statements is false?

A. The modulation transfer function of an imaging system is the magnitude of the Fourier transform of the point spread function of that system normalized by the Fourier transform at DC.

B. The modulation transfer function of an imaging system is a model of the noise and artifacts present in the system.

C. The modulation transfer function of an imaging system can be used to quantify the resolution of that system.

D. The modulation transfer function of an imaging system characterizes the contrast in the system.

E. The modulation transfer function of an imaging system can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

30. Which of the following statements is false?

A. It is possible to remove some artifacts from images in an efficient and automated fashion.

B. Artifacts degrade images in a repeatable or reproducible manner.

C. Noise can be modeled using probability and random variables, making it possible to reduce the effect of noise.

D. Artifacts can occur as a result of poor image reconstruction techniques.

E. A smaller signal-to-noise ratio is one indication that the output of a medical imaging system is of high image quality.

31. Which of the following imaging modalities is not one of the major modalities utilized in medical care in the United States?

A. Nuclear medicine

B. Ultrasound

C. Magnetic resonance imaging

D. Projection radiography

E. Magneto Encephalography

32. Which of the following statements is *false*?

A. In a sample of 10,000 people, the probability of someone having a height of exactly 5' 11" is zero.

B. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

C. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

D. In a sample of 10,000 coin tosses, the probability of getting exactly 4,900 heads is zero.

E. The uniform distribution describes equal probability across all values of a random variable.

33. Which of the following statements about image resolution is *false*?

A. Resolution is unrelated to the signal-to-noise ratio of an imaging system.

B. Resolution is related to the modulation transfer function of an imaging system.

C. High resolution in an image is characterized by "low smearing."

D. Resolution is related to the point spread function of an imaging system.

E. Resolution can be thought of as the ability of an imaging system to accurately depict two distinct events (in space, time, or frequency) as separate.

34. Which of the following imaging modalities uses very strong magnetic fields?

A. X-ray

B. MRI

C. Ultrasound

D. CT

E. PET

35. A coronal slice

A. represents a projection through the side of the body.

B. is parallel to the top of the head.

C. is parallel to the front of the body.

D. can be at any orientation relative to the patient.

E. divides the body into two roughly symmetrical halves.

36. The following are all true about tomographic images, *except*

A. Each pixel represents a localized sample in space.

B. Examples of tomographic image modalities includes MRI and CT.

C. They represent projections through the human body.

D. They are called 'tomographic' because *tomos* is Greek for 'slice'.

E. They can be coronal, sagittal, or axial.

37. The Greek letter ξ is written in English as

A. eta

B. xi

C. chi

D. phi

E. zeta

38. The following is (are) true about Signals and Systems as applied to imaging.

I - Where *time* is often the domain in conventional Signals and System, *distance* is often the domain in imaging.
II - Signals and Systems is usually applied in two or three dimensions in imaging.
III - The impulse function, convolution, and the Fourier transform are all commonly used in imaging.

A. None.

B. I and III

C. I and II

D. II only

E. I, II, and III

39. The following is (are) true about the impulse function in imaging:

I - It has an area of 1.
II - It can be used with integration to sample or "sift" another function.
III - It is infinitely high and infinitely narrow.

A. II only

B. I, II, and III

C. None.

D. I and II

E. I and III

40. The following are true about complex exponentials (expressions of the form $e^{j\theta}$) *except*

A. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

B. They are used to represent sinusoids in a format that is amenable to algebraic manipulation.

C. They cannot represent a purely real number.

D. They are central to Euler's identity.

E. The represent a complex number on the unit circle in the complex plain centered on the origin.

41. The Greek letter η is written in English as

A. phi

B. zeta

C. chi

D. xi

E. eta

42. A particular image consists of a sinusoidal variation in intensity along the x axis at a certain spatial frequency. Which of the following properties of that sinusoid may be changed by passing the image through a linear shift invariant system?

I - Amplitude.
II - Frequency.
III - Phase.

A. I and II.

B. I, II, and III.

C. I and III.

D. II and III.

E. I.

43. The following are all true about the Fourier transform applied to images, *except*

A. A given image has a single Fourier transform, but a given Fourier transform may result from a number of different images.

B. Rotating an image results in rotating its Fourier transform.

C. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

D. The Fourier transform of the projection of an image onto its x axis is the u axis of the Fourier transform of the original image.

E. The Modulation Transfer Function (MTF) of a linear shift invariant system is the Fourier transform of its impulse response (or Point Spread Function), normalized to the Fourier transform at the origin of the frequency domain.

44. The following are all true about frequencies above half the sampling frequency, *except*

A. In the frequency domain, they may result in bleeding into the neighboring Nyquist Sampling Period.

B. They may be mistakenly interpreted as lower frequencies.

C. In images, they may appear as Moire patterns, or "beat frequencies".

D. Their artifacts are generally avoided by removal in the discrete domain after sampling, rather than by filtering in the continuous domain before sampling.

E. The underlying discrete phasors may be viewed as a series of "snapshots" in which the phasors move further than 180 degrees between samples.

45. The following are all true about contrast, resolution, and noise in an imaging system *except*

A. Each can be described as a function of frequency.

B. They can be related to each other using mathematics that involves the Fourier transform.

C. They can each be quantified for an imaging system, although the method of quantification for each can be defined in various ways.

D. They can each effect the quality of an image and the accuracy of a diagnosis made from that image.

E. Increased noise tends to lead to increased contrast and increased resolution.

46. Which of the following statements is *false* about discrete random variables?

A. In physical system they are often described by a Poisson Distribution.

B. They can only assume integer values.

C. A probability distribution function can describe the distribution of values.

D. A probability mass function can describe the distribution of values.

E. A probability density function can describe the distribution of values.

47. The contingency table relates the results of a test to the presence of a disease, permitting the calculation of various quantities involving diagnostic accuracy, including all of the following, *except*

A. positive predictive value

B. prevalence

C. specificity

D. resolution

E. sensitivity

48. Find the period of the following signal: $sin(6\pi x)cos(2\pi y)$

A. $T_x = \frac{1}{2}$, $T_y = \frac{1}{2}$

B. $T_x = \frac{1}{3}$, $T_y = 1$

C. $T_x = 1$, $T_y = 1$

D. $T_x = 6$, $T_y = 2$

E. $T_x = 3$, $T_y = 1$

49. Given the signal $f(x,y) = x + y$: evaluate $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(x-1,y-2)dxdy$

A. $f(x-1,y-2)$
B. $f(x,y)$
C. $3\delta(x-1,y-2)$
D. 3
E. $f(x+1,y+2)$

50. Given $\mathcal{F}[f(x,y)] = F(u,v)$ and $\mathcal{F}[g(x,y)] = G(u,v)$, find $\mathcal{F}[f(x,y) * g(x,y)]$

A. $F(u,v) + G(u,v)$
B. $F(u,v)G(u,v)$
C. $F(u,v) * G(u,v)$
D. $F(u,v)G(u,v)e^{j2\pi(ux_0+vy_0)}$
E. $\frac{1}{|ab|}F(\frac{u}{a},\frac{v}{b}) * \frac{1}{|ab|}G(\frac{u}{a},\frac{v}{b})$

51. If $f(x,y) = e^{j2\pi(4x+y)}$ find $\mathcal{F}[f(x,y)]$, given $\mathcal{F}[e^{j2\pi xu_0}] = \delta(u-u_0)$

A. $e^{j2\pi(4x+y)}$
B. $4e^{j2\pi(4x+y)}$
C. $\delta(u-4,v-1)$
D. $\delta(u-5,v-5)$
E. $\frac{1}{4}\delta(\frac{u}{4},v)$

52. $f(x)$ and $g(x)$ are band limited signals with Nyquist sampling frequencies of 250 Hz and 100 Hz respectively. Find the Nyquist sampling frequency for $f(x) + g(x)$.

A. 200 Hz
B. 100 Hz
C. 500 Hz
D. 250 Hz
E. 350 Hz

53. If $\mathcal{F}[PSF] = \sqrt{5\pi}e^{-5\pi^2u^2}$ find the MTF. (*hint*: the Modulation Transfer Function (MTF) is the magnitude of the Fourier transform of the Point Spread Function (PSF), normalized by Fourier transform at 0 Hz.)

A. $e^{\frac{x^2}{5}}$
B. $e^{-5\pi^2u^2}$
C. $\sqrt{5\pi}e^{-5\pi^2u^2}$
D. $e^{5\pi^2u^2}$
E. $\sqrt{5\pi}$

54. If $h(x) = e^{\frac{-x^2}{2}}$, find the FWHM (Full Width Half Maximum).

A. $4\sqrt{2ln(\frac{1}{2})}$

B. $2\sqrt{2ln(\frac{1}{2})}$

C. $\sqrt{2ln(\frac{1}{2})}$

D. $2\sqrt{2ln(2)}$

E. $\sqrt{2ln(2)}$

55. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Diagnostic Accuracy.

A. 0.95

B. 0.67

C. 1.0

D. .10

E. .12

56. Consider the following continuous systems with input-output equations

I - $g(x, y) = f(x, y)^2$
II - $g(x, y) = 2f(x, y)$

Which system is (are) both linear and shift-invariant?

A. Cannot be determined

B. Neither of them

C. I and II

D. I

E. II

57. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*

A. It always has the same spatial frequency in the x direction as in the y direction.

B. It has a magnitude of 1.

C. It forms an orthogonal basis set from which any image can be constructed.

D. It represents a cosine in the real domain and a sine in the imaginary domain.

E. It is a separable function.

58. In the discrete domain, the following is (are) true about the probability *mass* function.

I - It represents the derivative of the probability *distribution* function.
II - It is a histogram with an area of 1.
III - It can never be negative.

A. I, II, and III.

B. I and II.

C. I and III.

D. None of them is true.

E. II and III.

59. The axial plane

A. represents a tomographic slice orthogonal to the long axis of the body.

B. is parallel to the front of the body.

C. is parallel to the coronal plane.

D. is parallel to the side of the body.

E. is used only in projection radiography.

60. Which of the following statements is *false* about the modulation transfer function (MTF) of an imaging system?

A. It is the Fourier transform of the point spread function (PSF) of that system normalized to the Fourier transform at DC.

B. It can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

C. It characterizes the contrast in the system.

D. It is always the same for any real imaging system.

E. It can be used to quantify the resolution of that system.

61. Which of the following statements is false?

A. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

B. The Probability *Distribution* Function is only applicable to continuous variables.

C. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

D. In a sample of 100,000 people, the probability of someone having a height of exactly 5' 6" is zero.

E. The random variable associated with the current temperature at the North Pole is a continuous random variable.

62. The Greek letter ψ is written in English as

A. zeta

B. phi

C. chi

D. psi

E. eta

63. The following are all true about the Fourier transform applied to images, *except*

A. Applying the Fourier transform to an image results (under ideal conditions) in no loss of information, and applying the inverse transform recreates the original image completely.

B. The Fourier transform of a real image function $f(x, y)$ consists of a function of frequency $F(u, v)$ that is always real, with no imaginary component.

C. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

D. Rotating an image results in rotating its Fourier Transform.

E. Convolution in the spatial domain corresponds to multiplication in the frequency domain.

64. A particular image consists the function $Asin(ux + \theta)$. Which of the following properties of that sinusoid may be changed by passing the image through a linear shift invariant system?

I - A.
II - u.
III - θ.

A. I.

B. I, II, and III.

C. I and II.

D. I and III.

E. II and III.

65. Given a continuous signal $f(x, y) = \frac{2x}{y^2}$, evaluate the following: $f(x, y)\delta(x + 1, y - 1)$

(Note that the impulse is not being integrated!)

A. -2

B. $\frac{2x}{y^2}$

C. $-2\delta(x + 1, y - 1)$

D. ∞

E. $-\infty$

66. The following is true of convolution, *except*

A. It exhibits the property of distributivity.

B. It exhibits the property of commutativity.

C. It can be used on signals in the temporal but not the spatial domains.

D. Convolution with the impulse function passes the other function through unchanged.

E. It requires the system to be linear to be meaningfully applied to the impulse response.

67. The concept of Resolution can be used in which of the following domains?

I - Spatial
II - Temporal
III - Spectral (frequency)

A. None of them is true.

B. I and II.

C. I and III.

D. I, II, and III.

E. II and III.

68. The following is true about the Hankel Transform *except*.

A. It does not have an inverse transform.

B. It requires circular symmetry.

C. It is the equivalent of the Fourier transform for functions where the spatial variable is radial distance.

D. It employs a Bessel function.

E. It always relates a function of a single variable to another function of a single variable.

69. Which of the following imaging modalities uses radio frequency electromagnetic fields?

A. CT

B. Ultrasound

C. X-ray

D. MRI

E. PET

70. You go to the emergency room with a cough that produces bloody phlegm and a fever, and the doctor says that based on these symptoms you may have tuberculoses. You are alarmed and ask what are the odds of having tuberculoses as an inhabitant of this part of the world, irrespective on these particular symptoms. Which of the following are you requesting?

A. Negative predictive value

B. Diagnostic accuracy

C. Prevalence

D. Sensitivity

E. Specificity

71. Which of the following statements is *false* about the modulation transfer function (MTF)?

A. The area under the MTF is always 1.

B. The MTF represents the attenuation of a sinusoidal spatial pattern at a particular frequency.

C. The MTF of an imaging system can be used to quantify the resolution of that system.

D. The MTF of an imaging system is the magnitude of the Fourier transform of the impulse response of that system normalized by the Fourier transform at DC.

E. The MTF at zero frequency is always 1, and at infinite frequency it is always 0.

72. The following are true about complex exponentials of the form $re^{j\theta}$ *except*

A. They can represent any complex number.

B. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

C. θ represents temporal or spatial frequency.

D. They are central to Euler's identity.

E. They are used to represent real sinusoids in a format that is amenable to algebraic manipulation, in which case a pair of complex conjugates must always be used.

73. The Greek letter ϕ is written in English as

A. zeta

B. psi

C. theta

D. chi

E. phi

74. Which of the following imaging modalities uses ionizing radiation? (pick best answer)

A. Only CT

B. Ultrasound and MRI

C. MRI and CT

D. Only MRI

E. Only ultrasound

75. The following is *not* true about the impulse function, $\delta(x)$.

A. It can be integrated and has an area of 1.

B. It can be translated to anywhere in the x domain.

C. It is also known as the Dirac function.

D. It can only be multiplied by a constant, and not by a variable function $f(x)$.

E. $\delta(0) = \infty$.

76. The following is true of a sagittal plane *except*

A. It is a projection through the body in the front-to-back direction.

B. It represents a tomographic slice.

C. It is perpendicular to axial planes.

D. It is perpendicular to coronal planes.

E. It may be a mid-sagittal plane, dividing the body into two roughly symmetrical halves.

77. The following is true of the Gaussian function of the form $\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. Convolution with another Gaussian always yields a Gaussian whose standard deviation σ is at least as large as the larger of the two constituent's σ.

B. It is always an even function.

C. It approaches an impulse function as σ approaches 0.

D. Multiplication with another Gaussian having the same mean μ yields a Gaussian with the same mean.

E. It approaches a constant function as σ approaches ∞.

78. Which of the following statements about the point spread function (PSF) is *false*?

A. It fully defines a linear shift-invariant system.

B. If a group of systems are connected in series, the PSF of the group is determined by convolving the PSFs of the individual systems, and cannot be narrower than any of the constituent PSFs.

C. It is sometimes characterized by the full width half maximum (FWHM), which for a Gaussian PSF is proportional to the standard deviation.

D. Resolution is limited by the PSF of a system.

E. It is always circularly symmetric (rotationally invariant).

79. The following is true about the Poisson distribution

A. It may represent continuous or discrete random variables.

B. It is used to represent variation between samples of high-energy photons in an x-ray image, leading to Rose's model for SNR.

C. It involves a complex exponential.

D. Its mean and standard deviation are equal.

E. It may be represented by a probability density function (pdf).

80. Which of the following statements is *false* about the probability mass function (PMF) described by the equation, $\Pr[N = \eta_i]$, for $i = 1, 2, ..., k$?

A. Its integral is a probability density function (pdf).

B. It represents a histogram of the probabilities of a discrete random variable.

C. $\sum_{i=1}^{k} \Pr[N = \eta_i] = 1$

D. An example of a PMF is the Poisson distribution.

E. It may be used to describe how many heads or tails are expected in 1000 coin tosses.

81. Consider the following continuous systems with input-output equations. Which statement is true?

I - $g(x,y) = [f(x,y)]^2$
II - $g(x,y) = 3f(x,y) + 2$

A. System II is linear.
B. Both systems are shift-invariant
C. Both systems are linear
D. System I is not shift invariant.
E. System I is linear.

82. Determine which of the following are periodic in both x and y.

I $\quad e^{j2\pi(ux+vy)} + e^{-j2\pi(ux+vy)}$, $u = 2, v = 3$

II $\quad \sum_{n=-\infty}^{\infty} \sum_{m=-\infty}^{\infty} \delta(x-n, y-m)$

III $\quad sinc(x)sinc(y)$

A. I, II, and III
B. I and II
C. II and III
D. I
E. I and III

83. Given a continuous signal $f(x,y) = x^2 - 3y$, evaluate the following: $2f(x,y)\delta(x+1, y-3)$

(Note that the impulse is not being integrated!)

A. $(x+1)^2 - 3(y-3)$
B. $-\infty$ for all x and y.
C. $2f(x,y)\delta(x^2, -3y)$
D. -16
E. $-16\delta(x+1, y-3)$

84. For each system with the following impulse response, determine which one is stable.

I - $h(x,y) = e^{x^2+y^2}\delta(x,y)$
II - $h(x,y) = x^{-y}$

A. I
B. Cannot be determined
C. I and II
D. Neither I nor II
E. II

85. A physical examination was used to screen for breast cancer in 2,500 women with biopsy-proven adenocarcinoma of the breast and in 2,500 age- and race-matched control women without the disease. The results of the physical examination were positive in 1,800 of the women with known adenocarcinoma and in 800 control women who showed no evidence of cancer at biopsy. Find the *specificity* of the physical examination

A. 50%,

B. 32%.

C. 68%

D. 70%.

E. 28%,

86. Which of the following statements about sampling is true?

A. Sampling artifacts consist of new frequencies not present in the original signal.

B. The application of a filter to a continuous signal prior to sampling is needed to eliminate all frequencies lower than the sampling frequency.

C. Sampling artifacts may be removed after sampling, provided they are due to frequencies lower than Nyquist frequency.

D. The Nyquist frequency is twice the lowest frequency present in the signal.

E. The Nyquist frequency is one-half of the highest frequency present in the signal.

87. Which of the following properties of the Fourier Transform is incorrectly shown?

A. Parseval's Theorem: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|f(x,y)|^2dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|F(u,v)|^2dudv$

B. Linearity: $F_{2D}(a_1f + a_2g)(u,v) = a_1F(u,v) + a_2G(u,v)$

C. Scaling: $F_{2D}(f(ax,by))(u,v) = \frac{1}{|ab|}F\left(au,bv\right)$

D. Translation/Shifting: $F_{2D}(f(x-x_0,y-y_0))(u,v) = F(u,v)e^{-j2\pi(ux_0+vy_0)}$

E. Convolution: $F_{2D}(f*g)(u,v) = F(u,v)G(u,v)$

88. Which of the following statements is *false*?

A. White noise is a particular type of noise that is easy to remove after the fact because it is correlated between pixels.

B. Increasing the signal-to-noise ratio is one indication that the image quality in a system has been improved.

C. Artifacts are generally not due to random events but rather to unwanted but specific effects of the system.

D. Distortion is due to geometric effects and is thus often reversible.

E. Noise is often modeled using probability and random variables.

89. Which of the following statements is *false*?

A. Resolution is limited by the lower frequencies in modulation transfer function of an imaging system.

B. Resolution and the signal-to-noise ratio of an imaging system are positively correlated.

C. Resolution can be thought of as the ability of an imaging system to accurately depict two distinct events (in space, time, or frequency) as separate.

D. Even a high resolution imaging system is ultimately limited by the pixel spacing.

E. Low resolution in an imaging system corresponds to a broad impulse response.

90. The following is true of the Power Signal-to-Noise Ratio (SNR) *except*

A. A Noise Power Spectrum (NPS) may be measured for *signal* noise or for *system* noise.

B. It is often preferred to Amplitude SNR, because Power SNR is easier to compute as a function of frequency (Parseval's theorem).

C. It is defined as the ratio of the power of the signal to the power of the noise.

D. The *signal* may vary in its power as a function of frequency, but *noise* always has the same power at all frequencies.

E. The mathematics of Power SNR takes advantage of Parseval's Theorem

91. Which of the following is your favorite part of the course so far? (Credit for all answers).

A. The metaphorical approach to the underlying mathematics.

B. The pictures from inside the human body.

C. The amazing machines and physics.

D. The equations.

E. The Prince and Links book.

92. The following is true about the sagittal plane, (or none is true)

A. It is commonly acquired as an image using projection radiography.

B. It is parallel to the top of the head.

C. It is parallel to the front of the body.

D. None is true.

E. It represents a projection through the side of the body.

93. The following are true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*, or all are true.

A. It represents a complex number as a function of x and y

B. It forms an orthogonal basis set from which any 2D image can be constructed.

C. It has an imaginary component, which can be cancelled by its complex conjugate.

D. All are true.

E. Pairs of these complex exponentials in an image form sinusoidal variations at a particular orientation, frequency, amplitude, and phase, as determined by the Fourier transform $F(u, v)$ of that image.

94. The following is *not* true about sequential convolution with an image by a series of point spread functions (PSFs), or all are true.

A. The entire process can be described as multiplying the spectrum of the image by the product of the spectra of all the PSFs.

B. If the PSFs are Gaussians, the standard deviation of the effective PSF is exactly the Pythagorean sum of the standard deviations of the individual PSFs.

C. All are true.

D. The entire process can be described as a single convolution with one combined PSF.

E. If one of the PSFs is much wider than all the others, the effective PSF of the entire process will be approximately the same width as that wider one.

95. Which of the following statements about sampling is true?

A. The Nyquist frequency is one-half of the highest frequency present in the signal.

B. Sampling artifact is due to the fact that phasors, when sampled less frequently than two times per revolution, "appear" to spin at a different frequency and/or in a different direction.

C. The Nyquist frequency is twice the lowest frequency present in the signal.

D. The application of a filter to a continuous signal prior to sampling is needed to eliminate the frequencies lower than the sampling frequency.

E. Sampling artifact is due to the fact that time is inherently not a continuous process, due to quantum effects.

96. A particular image consists the function $Asin(ux + \theta)$. Which of the following properties of that image will *not* be changed by passing it through a linear shift invariant system?

I - A.
II - u.
III - θ.

A. I.

B. III

C. II

D. I and III.

E. I, II, and III.

97. In the continuous domain, all of the following are true about the probability *density* function (pdf) *except*, (or all are true)

A. It always has an area of 1.

B. It can never be negative.

C. If the probability density function $p_N(\eta) \neq \infty$ then there is a zero probability of the exact value η.

D. All are true.

E. Its integral is the probability *distribution* function (PDF).

98. The following are true about the Poisson distribution *except*, or all are true.

A. All are true.

B. It is used to represent variation between samples of relatively small numbers of randomly occurring discrete events, such as high-energy photons striking a particular detector.

C. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf), since it cannot represent a continuous variable.

D. It has an area equal to the exponential constant, e, (approximately 2.718281828), because of the taylor series expansion.

E. Its mean and variance are equal.

99. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Specificity.

A. 0.67
B. .12
C. 0.95
D. .10
E. 1.0

100. Which of the following parameters of a phasor can be changed by a linear shift-invariant system?

A. phase and magnitude
B. phase, magnitude, and frequency
C. magnitude and frequency
D. frequency and phase
E. none of the other answers is correct

101. The following are all true about the function $rect(x, y)$, *except*

A. $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} rect(x, y)dxdy = 1$
B. It has circular symmetry.
C. It is non-periodic.
D. It is seperable.
E. $rect(x, y) = rect(x)rect(y)$.

102. If $h(x) = e^{-2x^2}$, find the FWHM (Full Width Half Maximum).

A. $\sqrt{2ln(2)}$
B. $2\sqrt{2ln(2)}$
C. $2\sqrt{2ln(\frac{1}{2})}$
D. $\sqrt{2ln(\frac{1}{2})}$
E. $4\sqrt{2ln(\frac{1}{2})}$

103. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Sensitivity.

A. .12

B. 0.67

C. 1.0

D. 0.95

E. .10

104. Which of the following statements is *true* about the modulation transfer function (MTF)?

A. The horizontal axis of the MTF is time.

B. The MTF of an imaging system is the magnitude of the Fourier transform of the impulse response of that system normalized by the Fourier transform at DC.

C. The MTF at zero frequency is always 0.

D. The area under the MTF represents the attenuation of the average (grayscale) intensity of the image through the system.

E. The area under the MTF is always 1.

105. The Greek letter Υ is written in English as

A. psi

B. upsilon

C. zeta

D. phi

E. chi

106. The following is true of the Gaussian function of the form $\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. Multiplication with another Gaussian yields a Gaussian whose standard deviation σ is smaller than either of the two constituents' σ.

B. Convolution with another Gaussian having the same mean μ always yields a Gaussian with the same mean μ

C. It approaches an impulse function as σ approaches 0.

D. It is an even function only when $\mu = 0$.

E. The function forms a legitimate probability density function (pdf) for any finite value of μ and finite and positive value of σ.

107. Which of the following statements is *false* about the probability mass function (PMF) described by the equation, $\Pr[N = \eta_i]$, for $i = 1, 2, ..., k$?

A. $\sum_{i=1}^{k} \Pr[N = \eta_i] = 1$

B. An example of a PMF is the Poisson distribution.

C. It represents a histogram of the probabilities of a discrete random variable.

D. Although i is an integer, η_i does not need to be an integer, just a particular value for the discrete random variable N.

E. The actual probability for any particular value of N is infinitely small.

108. Given the signal $f(x, y) = x + y$: evaluate $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y)\delta(x + 1, y - 2)dxdy$

A. $3\delta(x + 1, y - 2)$

B. 3

C. $f(x, y)$

D. 1

E. $f(x + 1, y - 2)$

109. Which of the following properties of the Fourier Transform is *incorrectly* shown?

A. Linearity: $F_{2D}(a_1 f + a_2 g)(u, v) = a_1 F(u, v) + a_2 G(u, v)$

B. Translation/Shifting: $F_{2D}(f(x - x_0, y - y_0))(u, v) = F(u, v)e^{-j2\pi(ux_0 + vy_0)}$

C. Convolution: $F_{2D}(f * g)(u, v) = F(u, v) + G(u, v)$

D. Parseval's Theorem: $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |f(x, y)|^2 dxdy = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |F(u, v)|^2 dudv$

E. Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$

110. The following is *false* about the Fourier transform $F(u, v)$ of image $f(x, y)$, (or all are true).

A. All are true.

B. The average, or 'DC', value of the image $f(x, y)$ is a real number located at $F(0, 0)$

C. The Fourier transform of the projection of an image onto its x axis is a 1D function, equal to the value of the Fourier transform of the original image along its u axis.

D. Rotating an image results in rotating its Fourier Transform.

E. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

111. Which of the following statements about resolution is *false*?

A. Spatial resolution is limited by the number of pixels or voxels per cm, but may also be further limited by the image acquisition or subsequent filtering.

B. Temporal resolution is limited by the number of images acquired per unit time.

C. The Full Width Half Maximum (FWHM) fully defines the resolution, without requiring any further knowledge about the Point Spread Function (PSF).

D. 'Spectral resolution' refers to the ability to distinguish one frequency from another, and is necessarily limited in the Fourier transform of a sampled image.

E. Spatial resolution may be defined in terms of the Modulation Transfer Function (MTF), which, in practice, may be said to have a cut-off frequency, whose inverse is the resolution.

112. For a cascade of subsystems with Full Width Half Maxima (FWHM) of $R_1, R_2, R_3, \ldots, R_k$, with each subsystem having any possible Point Spread Function (PSF), which of the following statements is *false*, or all are true?

A. The PSF of the entire cascade will exactly equal the convolution of the individual PSFs with each other, in any particular order and grouped in any manner.

B. The total FWHM of the cascade will exactly equal the Pythagorean sum of the individual FWHMs, $R = \sqrt{{R_1}^2 + {R_2}^2 + {R_3}^2 + \ldots + {R_k}^2}$.

C. The FWHM of a Gaussian PSF is directly proportional to its standard deviation.

D. All are true.

E. The system with the poorest resolution (largest R) dominates.

113. Which of the following statements about random variables $N_1, N_2, N_3, \ldots, N_m$, whose probability density functions (pdf's) are $p_1(\eta), p_2(\eta), p_3(\eta), \ldots, p_m(\eta)$, is *false* about the sum of those random variables, N_S, or all are true?

A. N_S will have a mean of $\mu_S = \mu_1 + \mu_2 + \mu_3 + \ldots + \mu_m$.

B. All are true.

C. N_S will have a variance of $\sigma_S^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \ldots + \sigma_m^2$.

D. The probability density function of N_S will be the product of the individual pdf's, $p_S(\eta) = p_1(\eta) \times p_2(\eta) \times p_3(\eta) \times \ldots \times p_m(\eta)$.

E. N_S will have a pdf whose area equals 1.

114. Which of the following imaging modalities is not inherently tomographic?

A. CT

B. PET

C. Ultrasound

D. MRI

E. Fluoroscopy

115. The following is true statements about decibels *except*

A. They are named in honor of the inventor of the telephone.

B. If the amplitudes of two signals, A and B, are V_A and V_B, respectively, the number of decibels increasing from A and B is $20 \times log_{10} \frac{V_B}{V_A}$.

C. They are often used as the unit for Signal to Noise Ratio (SNR), where, if the noise has a Poisson distribution, the mean μ represents the noise and the standard deviation σ represents the signal.

D. They provide a scale whose dynamic range better matches that of human perception (e.g. of sound and light) than would a linear scale.

E. Decibels, denoted as 'dB', represent a pure fraction without dimension.

116. You go to the emergency room with a cough that produces bloody phlegm and a fever, and the doctor says that based on these symptoms you may have tuberculoses (TB). You are alarmed and ask how likely it is to have TB, given those symptoms. Which of the following are you requesting?

A. Diagnostic accuracy

B. Sensitivity

C. Prevalence

D. Positive predictive value

E. Specificity

117. The following are true about complex exponentials of the form $re^{j\theta}$ *except*

A. When multiplied together, they scale each other's magnitudes and rotate each other's phase.

B. θ may represent temporal or spatial phase.

C. They can be used to represent real sinusoids in a format that is amenable to algebraic manipulation, by using complex conjugates to eliminate the imaginary component.

D. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

E. They can represent any complex number except 0, because $re^{j0} = 1$

118. Which of the following statements about the point spread function (PSF) is *false*?

A. It fully defines a linear shift invariant system.

B. If the PSF is a delta function with area 1, then the system does not change the signal passing through it.

C. Resolution is limited by the PSF of a system.

D. The PSF is the Fourier Transform of the impulse response.

E. If it is circularly symmetric, then the Modulation Transfer Function (MTF) is rotationally invariant.

119. The following is true of the Power Signal-to-Noise Ratio (SNR) *except*, or all are true.

A. For white noise, the power of the *noise* is constant with frequency.

B. All are true.

C. It is defined as the ratio of the power of the signal to the power of the noise.

D. The *signal* and *noise* may each vary in their power as a function of frequency.

E. It is often preferred to Amplitude SNR, because Power SNR is easier to express as a function of frequency, by using Parseval's Theorem.

120. The following are true about Receiver Operator Characteristic (ROC) curves *except* (or all are true):

A. They represent a plot of sensitivity vs. (1-specificity) over a range of thresholds.

B. A test that produces random results has an area under the curve of 1/2.

C. They express the precision of a test but not the accuracy.

D. All are true.

E. The plot always proceeds from (0,0) and ends at (1,1).

121. Which of the following is *false* about the Mass Spectrometer, (or all are true):

A. It accelerates ions using a large electrostatic field.

B. It can differentiate between the numbers of neutrons in atoms with the same atomic number.

C. It separates isotopes by differences in mass.

D. All are true.

E. It bends the paths of ions using a magnetic field.

122. An impulse response $h(x, y)$ is represented by the function

$$h(x,y) = \begin{cases} 1-\sqrt{x^2+y^2}, & x^2+y^2<1 \\ 0, & \text{otherwise} \end{cases}$$

The following are true *except* (or all are true):

A. The impulse response has circular symmetry

B. The Modulation Transfer Function (MTF) of this function is the Fourier transform $H(u, v)$ of $h(x, y)$ normalized by $H(0, 0)$.

C. The Fourier transform $H(u, v)$ of $h(x, y)$ has circular symmetry.

D. The full width half-maximum is equal to 1.0.

E. All are true.

123. The following is true of the Gaussian probability density function (pdf), $p_N(\eta) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(\eta-\mu)^2}{2\sigma^2}}$ *except* (or all are true).

A. The area under $p_N(\eta)$ is always 1.

B. All are true.

C. The "expected" value $E[N] = \mu$, no matter what the value of σ.

D. The standard deviation of a population with this pdf is σ^2.

E. Its integral is a Probability Distribution Function (PDF) which contains a particular function commonly called "the error function"

124. The following are true about sequential convolution with an image by a series of point spread functions (PSFs) *except* (or all are true).

A. All are true.

B. If the PSFs are Gaussians, the standard deviation of the effective PSF is exactly the Pythagorean sum of the standard deviations of the individual PSFs.

C. The PSF for the entire process is always wider (worse resolution) than for any of the contributing PSFs.

D. The entire process can be described as multiplying the Fourier transform of the image by the product of the Fourier transforms of all the PSFs.

E. The entire process can be described as a single convolution with one combined PSF.

125. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*, (or all are true).

A. Complex conjugate pairs of these complex exponentials form real sinusoidal variations at particular orientations and frequency in space.

B. It is always real at the origin (x, y), no matter what the frequencies (u_0, v_0) are.

C. Its maximum spatial frequency is in the (u_0, v_0) direction.

D. It can be scaled and shifted in phase by multiplication with a complex number, but not changed in frequency.

E. All are true.

126. The following are true about the Poisson distribution $Pr[N = k] = \frac{a^k}{k!}e^{-a}$, where a is a constant, *except* (or all are true).

A. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf)

B. It is used to represent variation between samples of relatively few events, such as the number of high energy photons hitting a detector per unit time.

C. The probability that $k = 0$ is always zero.

D. All are true.

E. Its mean and variance are equal.

127. Consider the following continuous systems whose outputs $g(x, y)$ are related to their inputs $f(x, y)$ as follows:

I - $g(x, y) = 2 - f(x, y)$
II - $g(x, y) = [f(x, y)]^2$

Which system is (are) both linear and shift-invariant?

A. I

B. Neither of them

C. Both I and II

D. Cannot be determined from the information given.

E. II

128. Which of the following properties of the Fourier Transform is incorrectly shown?

A. Convolution: $F_{2D}(f * g)(u, v) = F(u, v)G(u, v)$

B. Translation/Shifting: $F_{2D}(f(x - x_0, y - y_0))(u, v) = F(u - u_0, v - v_0)$

C. Parseval's Theorem: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |f(x, y)|^2 dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |F(u, v)|^2 dudv$

D. Linearity: $F_{2D}(a_1 f + a_2 g)(u, v) = a_1 F(u, v) + a_2 G(u, v)$

E. Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$

129. The following are all true about the Fourier transform applied to images, *except*

A. Rotating an image results in rotating its Fourier transform.

B. The Modulation Transfer Function (MTF) of a linear shift invariant system is the Fourier transform of its impulse response (or Point Spread Function), normalized to the Fourier transform at the origin of the frequency domain.

C. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

D. A given image has a single Fourier transform, but a given Fourier transform may result from a number of different images.

E. The Fourier transform of the projection of an image onto its x axis is the u axis of the Fourier transform of the original image.

130. The following are all true about frequencies above half the sampling frequency, *except*

A. The underlying discrete phasors may be viewed as a series of "snapshots" in which the phasors move further than 180 degrees between samples.

B. They may be mistakenly interpreted as lower frequencies.

C. Their artifacts can only be avoided by guaranteeing no frequency components above half the sampling frequency are present in the continuous domain *before* sampling.

D. In images, they may appear as Moire patterns, or "beat frequencies".

E. Artifacts may be avoided by inclusion of the complex conjugate phasor at the corresponding negative frequency.

131. Given the signal $f(x, y) = x^2 - y$: evaluate $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x, y)\delta(x + 3, y - 1)dxdy$

A. Cannot be evaluated since $f(x, y)$ is not linear.

B. $f(x + 3, y - 1)$

C. $\delta(x + 3, y - 1)$

D. 8

E. $8\delta(x + 3, y - 1)$

132. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Specificity.

A. 1.00

B. ∞

C. .66

D. 0.95

E. 0.5

133. The following is (are) true about the probability *mass* function.

I - It is the integral of the Probability Distribution Function (PDF)
II - It can only be used for discrete random variables.
III - It can never be negative.

A. III

B. I, II, and III.

C. II and III.

D. I and III.

E. I and II.

134. Which of the following statements about the point spread function (PSF) is *false*?

A. Resolution is limited by the PSF of a system.

B. It is the Fourier transform of the response to the impulse function.

C. It is sometimes characterized by the full width half maximum (FWHM), which for a Gaussian PSF is proportional to the standard deviation.

D. It fully defines a linear shift-invariant system.

E. It can be circularly symmetric (rotationally invariant), but does not have to be.

135. For a cascade of subsystems with Full Width Half Maxima (FWHM) of $R_1, R_2, R_3, \ldots, R_k$, with each subsystem having its own Point Spread Function (PSF), which of the following statements is *false*, or all are true?

A. The PSF of the entire cascade will exactly equal the convolution of the individual PSFs with each other, in any particular order and grouped in any manner.

B. The FWHM of a Gaussian PSF is directly proportional to its standard deviation.

C. All are true.

D. For Gaussian PSFs, the total FWHM of the cascade will exactly equal the Pythagorean sum of the individual FWHMs, $R = \sqrt{{R_1}^2 + {R_2}^2 + {R_3}^2 + \ldots + {R_k}^2}$.

E. The system with the poorest resolution (largest R) dominates.

136. The following are true about complex exponentials of the form $re^{j\theta}$ *except* (or all are true).

A. They are used to represent real sinusoids in a format that is amenable to algebraic manipulation, in which case a pair of complex conjugates must always be present.

B. All are true.

C. When multiplied together, they scale each other's magnitudes and rotate (add) each other's phase.

D. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

E. In a 1-dimensional signal vs. time, θ may be replaced with ωt (rotational frequency $\times$ time).

137. Which of the following statements is *incorrect*?

A. The scaling property of the Fourier transform can be written as $F_{2D}(f(ax, by)) = \frac{1}{|ab|}F(\frac{u}{a}, \frac{v}{b})$.

B. The Hankel transform of the *rect* function is a *sinc* function.

C. Given the convolution $f(x, y) * g(x, y)$ in spatial domain, its Fourier transform will be $F(u, v)G(u, v)$ in frequency domain.

D. Both *sinc(x)* and *jinc(x)* have defined finite values when x = 0.

E. If $f(x, y)$ is rotated by an angle θ, then its Fourier transform is rotated by angle θ as well

138. Which of the following is *true* about image quality?

A. All are true.

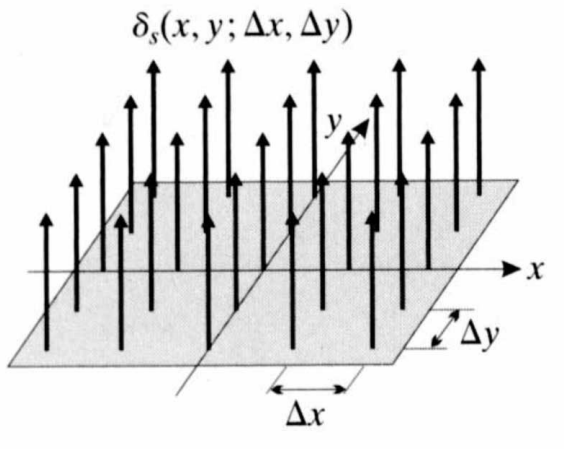
B. The Signal to Noise Ratio (SNR) is often computed as a ratio where the mean μ represents the noise and the standard deviation σ represents the signal.

C. The difference between the target and its background is captured by the *local contrast*, defined as $C = \frac{f_t}{f_b}$.

D. Given a cascade LSI system, if the FWHM of its subsystems have the relationship $R_1 > R_2 > R_3$, the resolution of the overall system is dominated by subsystem R_3.

E. The MTF quantifies degradation of contrast as a function of spatial frequency. So for most medical imaging systems for every u, we have $0 \leq MTF(u) \leq MTF(0) = 1$.

139. Which of the following is *false* about the mathematical function shown below (or all of the others are true)?



A. Its Fourier transform is another such function.

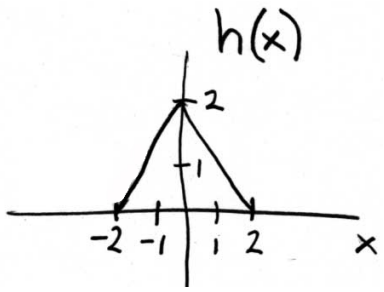
B. It is generally represented mathematically as the sum of a set of displaced impulse functions.

C. All of the others are true.

D. It is used to sample continuous data in the spatial domain (by means of multiplication in the spatial domain).

E. Its Fourier transform accounts for repetition in the frequency domain (by means of convolution in the frequency domain) when continuous data in the spatial domain is sampled.

140. What is the Full Width Half Maximum (FWHM) of the following impulse response (one-dimensional Point Spread Function)?



A. 0.5

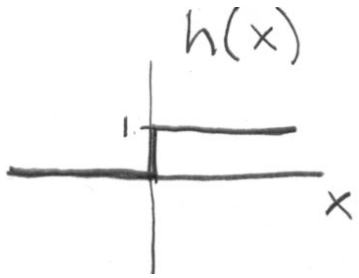
B. 4

C. None of the other answers is correct

D. 1

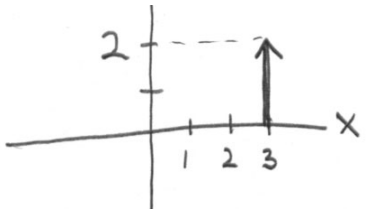
E. 2

141. Assuming $g(x) = f(x) * h(x)$, for the $h(x)$ shown below, which of the following is true?



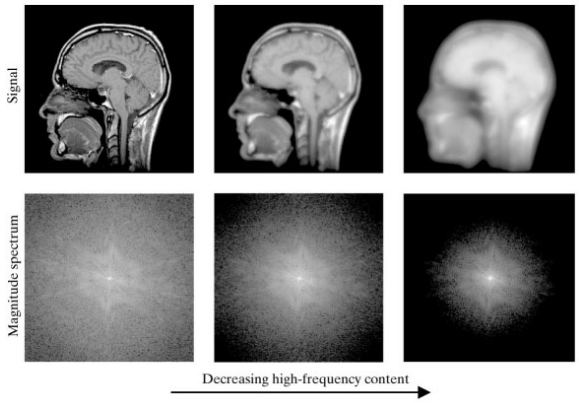
A. $g(x) = \int_{-\infty}^{x} f(\xi)d\xi$.
B. None of the other answers is correct
C. $g(x) = f(x)$
D. $g(x) = \frac{df(x)}{dx}$
E. $g(x) = f(x)h(x)$

142. Assuming $g(x) = f(x) * h(x)$, for the $h(x)$ shown below, which of the following is true?



A. $g(x) = 2f(x - 3)$.
B. $g(x) = 2f(x + 3)$
C. $g(x) = 6f(x)$
D. $g(x) = 3 - f(2x)$
E. None of the other answers is correct

143. Given the images below and their corresponding Fourier transforms, showing an original scan followed by convolution with a 2D Gaussian, which of the following statements is *false* (or all are true)?



A. For each of the Fourier magnitude transforms, there is a corresponding phase transform that is not shown.

B. The Fourier transforms (from left to right) show decreasing magnitudes in the high frequencies, which are furthest from the center of each transform as shown.

C. All are true.

D. The original image (upper left) is a sagittal slice through a human head.

E. A given location in each Fourier transform represents a phasor with a particular horizontal and vertical frequency component.

144. Given the following function, which of the following statements is *false*?

$f(x,y) = \frac{e^{j2\pi(x+y)}+e^{-j2\pi(x+y)}}{2}$

A. $f(x,y)$ is periodic.

B. $f(x,y)$ varies sinusoidally along a direction described by the vector (1,1) in the (x,y) plane.

C. $f(0,0)$=1.

D. The value of $f(x,y)$ approaches infinity exponentially.

E. $f(x,y)$ has a real value for all x and y because it consists of two phasors that are complex conjugates of each other.

145. The equation,

$F(u,v) = |F(u,v)|e^{j\angle F(u,v)}$,

demonstrates the following attributes of the Fourier transform, $F(u,v)$, *except* (or all are true).

A. $F(u,v)$ is a complex number.

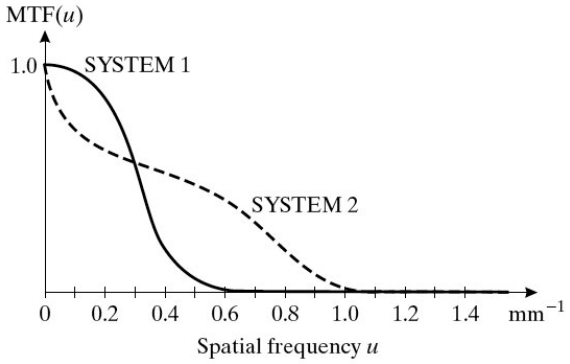
B. All are true.

C. $|F(u,v)|$ is a real number, while $e^{j\angle F(u,v)}$ is a complex number with a magnitude of 1.

D. $F(u,v)$ consists of a magnitude and a phase.

E. $F(u,v)$ is a phasor that varies (rotates) as a function of space (x and y).

146. Given the figure shown below, which of the following statements is *true* (or none is true)?



A. System 1 has a superior resolution to System 2.

B. Both System 1 and System 2 represent, in frequency domain, Gaussian Point Spread Functions (PSFs) in the spatial domain.

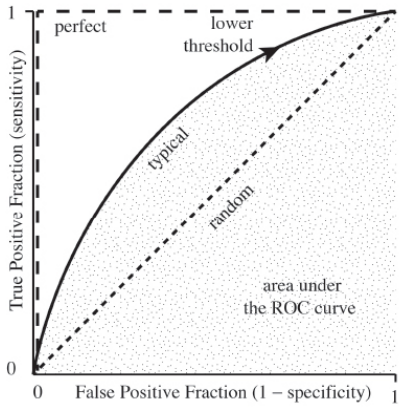
C. System 2 has a superior resolution to System 1.

D. None of the other answers is true.

E. Resolution cannot always be expressed by a single value.

147. Assuming the area under an ROC curve is 1 for a given diagnostic test for a certain disease, which of the following statements about the test is *true* (or all are false)?

Receiver Operator Characteristics (ROC) Curve



A. All are false.

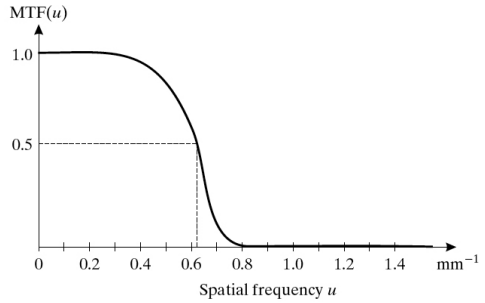
B. The sensitivity and the specificity are both equal to 1.

C. The diagnostic test is worthless.

D. The prevalence of the disease is zero.

E. There may be many false negatives, but no false positives.

148. Given the following isotropic Modulation Transfer Function (MTF) for an imaging system, which of the following statements is *false* (or all are true)?



A. This MTF is the Fourier transform of a 1D cross-section of the Point Spread Function (PSF) normalized to 1.0 at spatial frequency 0.

B. All are true.

C. This MTF implies that the Point Spread Function (PSF) must be an impulse function.

D. The attenuation of the system increases monotonically with spatial frequency.

E. The Full Width Half Maximum (FWHM) is approximately 2×0.62 cycles/mm.

149. Given the following function, which of the following statements is *false*, (or all are true)?

$f(x,y) = \frac{e^{j2\pi(x+y)} + e^{-j2\pi(x+y)}}{2}$

A. The value of $f(x,y)$ has a maximum value of 1.

B. $f(x,y)$ varies sinusoidally along a direction described by the vector (1,1) in the (x,y) plane.

C. $f(x,y)$ is periodic with a period of 2, in the direction of its minimum period.

D. All are true.

E. $f(x,y)$ has a real value for all x and y because it consists of two phasors that are complex conjugates of each other.

For official use only
permutation number = 1232

BioE 1330 - Review Intro and Chapters 1, 2, and 3 9/27/2018
Answer Sheet - Correct answer is A for all questions

1. Which of the following imaging modalities do not use ionizing radiation? (pick best answer)

A. Ultrasound and MRI

B. Only CT

C. Only MRI

D. Ultrasound and CT

E. Only ultrasound

Explanation: CT uses X-Rays which are ionizing radiation, MRI uses magnetic fields and radio frequencies which are not ionizing (only frequencies at ultraviolet and above are ionizing). Ultrasound does not ionize tissue.
[*imaging0001.mcq*]

2. The mid-sagittal plane

A. divides the body into two roughly symmetrical halves.

B. is parallel to the top of the head.

C. represents a projection through the side of the body.

D. is parallel to the front of the body.

E. is only used in CT but not MRI.

Explanation: The mid-sagittal plane divides the left and right halves of the body. It may be used in any 3D imaging modality.
[*imaging0002.mcq*]

3. The sagittal plane

A. is perpendicular to the coronal plane.

B. is parallel to the top of the head.

C. represents a projection through the side of the body.

D. is parallel to the front of the body.

E. is used only in projection radiography.

Explanation: The sagittal plane is parallel to the side of the body and is perpendicular to the other two planes (coronal and axial). It may be used in any 3D tomographic imaging modality, but not in projection radiography).
[*imaging0003.mcq*]

4. The following is not true about the impulse function, $\delta(x)$.

A. It cannot be integrated.

B. It is also known as the Dirac function.

C. $\delta(0) = \infty$.

D. It has an area of 1.

E. It is infinitely narrow.

Explanation: The impulse (delta, or Dirac) function is infinitely narrow, infinitely tall, with an area of 1.
[*imaging0004.mcq*]

5. Computerized Tomography (CT)

A. depends on multiple projections of X-rays from many angular orientations to compute a slice of voxels.

B. requires extremely strong magnetic fields.

C. requires the use of radioactive isotopes.

D. is primarily used to image physiological function rather than anatomical structure.

E. cannot be used to produce a 3D set of voxels.

Explanation: CT is based on X-rays, not magnetic fields or radioactive elements. It images primarily anatomical structure and depends on multiple angles of projection to compute a slice using a technique called back-projection.
[*imaging0005.mcq*]

6. The following is true of the Gaussian function, generally of the form $\frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. It represents a cosine in the real domain and a sine in the imaginary domain.

B. Multiplication with another Gaussian having the same mean μ yields a Gaussian with the same mean.

C. Convolution with another Gaussian always yields a Gaussian whose standard deviation σ is at least as large as the larger of the two constituent's σ.

D. When $\mu = 0$, the Gaussian is an even function.

E. It approaches an impulse function when σ approaches 0.

Explanation: The complex exponential, not the Gaussian, represents the cosine in the real domain and a sine in the imaginary domain
[*imaging0006.mcq*]

7. The following is true of convolution, *except*

A. Convolution with a Gaussian applied to any function $f(x)$ yields the same function $f(x)$.

B. It can be used on signals in both the temporal and spatial domains.

C. It exhibits the property of commutativity.

D. It exhibits the property of associativity.

E. Convolution in the temporal (or spatial) domain is equivalent to multiplication in the frequency domain.

Explanation: Convolution with an impulse function (not a Gaussian) applied to any function $f(x)$ yields the same function $f(x)$.
[*imaging0007.mcq*]

8. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*

A. It has an imaginary component, making it incapable of being used in the construction of real images.

B. Complex conjugate pairs of these complex exponentials form real sinusoidal variations at particular orientations and frequency in space.

C. It forms an orthogonal basis set from which any image can be constructed.

D. It represents a cosine in the real domain and a sine in the imaginary domain.

E. It is a periodic function.

Explanation: The complex exponential does have an imaginary component, but complex conjugate pairs are added together to cancel that component.
[*imaging0008.mcq*]

9. Which of the following statements is true about the Bessel function?

I - They are a family of functions, specified by kind and order.
II - They exhibit circular symmetry and can represent waves passing through an aperture.
III - Convolution of a function $f(x, y)$ with a Bessel function yields a Rect function.

A. I and II.

B. I and III.

C. II and III.

D. I, II, and III.

E. I.

Explanation: III is a nonsense statement, as $f(x, y)$ is unspecified.
[*imaging0009.mcq*]

10. Which of the following statements *best* summarizes why a sampled function in the spatial domain is periodic in the frequency domain.

A. A sampled complex exponential can take an unknown number of complete revolutions in the complex plane between one sample and the next.

B. An impulse function in the discrete domain has an amplitude of 1.

C. Positive and negative frequencies represent complex conjugate pairs of complex exponentials.

D. Convolution with a Step function is equivalent to integration.

E. A low pass filter applied before sampling is required if frequencies exist in the continuous domain above the Nyquist frequency.

Explanation: The sampled complex exponential is "periodic" because of the ambiguity caused by sampling; it can take extra revolutions from one sample to the next.
[*imaging0010.mcq*]

11. The following are true about the Modulation Function $m_f = \frac{f_{max}-f_{min}}{f_{max}+f_{min}}$ of $f(x, y)$, *except*

A. It equals $\frac{1}{2}$ when there is no contrast in the image.

B. It is always in the range $0 \leq m_f \leq 1$.

C. It is a measure of the contrast in an image.

D. For a sinusoidal variation in intensity, it represents the amplitude of the sinusoid over its average value.

E. It equals 1 only when$f_{min} = 0$.

Explanation: It equals 0 when there is no contrast in the image.
[*imaging0011.mcq*]

12. In the continuous domain, the following are true about the probability *density* function.

I - It represents the derivative of the probability *distribution* function (also called the "cumulative distribution function".
II - It has an area of 1.
III - It can never be negative.

A. I, II, and III.

B. I and II.

C. II and III.

D. I and III.

E. None of them is true.

Explanation: All are true.
[*imaging0013.mcq*]

13. The following are true about the Poisson distribution *except*

A. It may represent continuous or discrete random variables.

B. It is used to represent variation between samples of high-energy photons in an x-ray image.

C. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf)

D. It can model randomly occurring discrete events.

E. Its mean and variance are equal.

Explanation: The Poisson distribution can only represent discrete variables.
[*imaging0014.mcq*]

14. Consider the following continuous systems whose output $g(x, y)$ is related to its input $f(x, y)$ as follows:

I - $g(x, y) = 2f(x, y)$
II - $g(x, y) = xyf(x, y)$

Which system is (are) both linear and shift-invariant?

A. I

B. II

C. I and II

D. Neither of them

E. Cannot be determined

Explanation: A system is linear if, when the input consists of a collection of signals, the output is the summation of the responses of the system of each of those individual input signals. A system is shift-invariant if an arbitrary translation of the input signal results in an identical translation of the output.
[*imaging0015.mcq*]

15. Determine which of the following signals are separable.

I rect(x,y)
II sinc(x, y)
III $\delta(x, y)$

A. I, II, and III

B. II

C. I and II

D. I and III

E. I

Explanation: All are separable.
[*imaging0016.mcq*]

16. Determine which of the following signals are periodic in both x and y.

I - comb(x,y)
II - $\delta(x, y)$
III- $f(x, y) = \sin(\frac{x+y}{5m}) + \cos(\frac{x+y}{5n})$, for all real numbers $m \neq n$

A. I

B. II

C. I and II

D. II and III

E. I, II, and III

Explanation: Function I is clearly periodic in both x and y. Function II clearly is not periodic at all, being just a single impulse. Function III is the sum of 2 sinusoids, both in the same direction along the diagonal $x = y$, so each sinusoid on its own is periodic in both x and y, but since neither m nor n are guaranteed to be rational numbers, it is not guaranteed that there is some multiple of m and n that is an integer, and so the function is not guaranteed to be periodic.
[*imaging0017.mcq*]

17. Given a continuous signal $f(x, y) = x + y^2$, evaluate the following: $f(x, y)\delta(x - 2, y - 1)$

(Note that the impulse is not being integrated!)

A. $3\delta(x - 2, y - 1)$

B. $(x - 2) + (y - 1)^2$

C. 3

D. $x + y^2$

E. 5

Explanation: Since there is no integration happening, (this is not "sifting") the delta function remains in the answer.
[*imaging0018.mcq*]

18. For each system with the following PSF, determine which one is stable.

I - $h(x, y) = x^2 + y^2$
II - $h(x, y) = x^2 e^{-y^2}$

A. Neither of them

B. II

C. I and II

D. I

E. Cannot be determined

Explanation:
[*imaging0019.mcq*]

19. Match following terms with their definitions

a - Contrast
b - Resolution
c - Noise
d - Artifacts
e - Distortion

1 - is any geometric inaccuracy in size or shape.
2 - is any random fluctuation in an image.
3 - is the ability of an imaging system to distinguish neighboring points in space, time, or energy as distinct.
4 - the difference in image intensity of an object or target and surrounding objects or background.
5 - are false signals in an image that do not represent any valid structural or functional signal in the patient.

A. a - 4, b - 3, c - 2, d - 5, e - 1

B. a - 2, b - 5, c - 1, d - 3, e - 4

C. a - 4, b - 3, c - 2, d - 1, e - 5

D. a - 3 , b - 4 , c - 2, d - 5, e - 1

E. a - 4, b - 3, c - 5, d - 2, e - 1

Explanation: See definitions in book.
[*imaging0020.mcq*]

20. Select the statement that best describes the field of Medical Imaging.

A. All of the other statements.

B. Integrates Bioengineering, Biology, and Medicine.

C. Can be used for Diagnosis and Therapy.

D. Requires training in computational and life sciences.

E. Is a multidisciplinary area.

Explanation: The are all true(isms).
[*imaging0021.mcq*]

21. Which one of the following statements is true? The two medical imaging techniques, CT (Computed Tomography) and MRI (Magnetic Resonance Imaging), are complimentary because

A. CT differentiates tissues by their attenuation of x-rays while MRI differentiates the local environments of hydrogen nuclei.

B. CT images bone differently from soft tissue whereas MRI does not.

C. MRI uses ionizing radiation whereas CT does not.

D. MRI is a tomographic modality whereas CT is not.

E. None of the other statements is true.

Explanation: Answer A is correct.
[*imaging0022.mcq*]

22. Which of the following statements is true?

A. None of the other statements is true.

B. PET and MRI are examples of emission imaging.

C. MRI relies on nuclear resonance and CT on emission of radiation by tissue.

D. Ultrasound is the only imaging modality that does not use ionizing radiation.

E. X-rays, CT, and PET are all examples of transmission imaging.

Explanation: None are true.
[*imaging0023.mcq*]

23. A physical examination was used to screen for breast cancer in 2,500 women with biopsy-proven adenocarcinoma of the breast and in 5,000 age- and race-matched control women without the disease. The results of the physical examination were positive in 1,800 of the women with known adenocarcinoma and in 800 control women who showed no evidence of cancer at biopsy. Find the *sensitivity* of the physical examination

A. 72.0

B. 84.0

C. 69.2

D. 28.0

E. 36.0

Explanation: $(1800/2500) * 100$
[*imaging0024.mcq*]

24. Which of the following statements about sampling is true?

A. Sampling explains why we sometimes see movies with cars that appear to have wheels turning backwards.

B. The Nyquist frequency is one-half of the highest frequency present in the signal.

C. The Nyquist frequency is twice the lowest frequency present in the signal.

D. The application of a filter to a continuous signal prior to sampling is needed to eliminate the frequencies lower than the sampling frequency.

E. Sampling rate is unrelated to the presence of aliasing in a signal.

Explanation: Continuous signals must be sampled in order to be stored and processed digitally. Signals should be sampled at a frequency greater than the signal's Nyquist frequency, which is twice the highest frequency present in that signal, to avoid aliasing of the signal (and subsequent loss of information). Filters are employed to get rid of high frequencies prior to sampling, not low frequencies.
[*imaging0025.mcq*]

25. Which of the following properties of the Fourier Transform is incorrectly shown?

A. Parseval's Theorem: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|f(x,y)|dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|F(u,v)|dudv$

B. Linearity: $F_{2D}(a_1 f + a_2 g)(u,v) = a_1 F(u,v) + a_2 G(u,v)$

C. Translation/Shifting: $F_{2D}(f(x-x_0, y-y_0))(u,v) = F(u,v)e^{-j2\pi(ux_0+vy_0)}$

D. Scaling: $F_{2D}(f(ax,by))(u,v) = \frac{1}{|ab|}F\left(\frac{u}{a},\frac{v}{b}\right)$

E. Convolution: $F_{2D}(f * g)(u,v) = F(u,v)G(u,v)$

Explanation: All of the properties are correctly written except Parseval's Theorem, which relates the squares of the magnitudes of the function and its Fourier Transform: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|f(x,y)|^2dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}|F(u,v)|^2dudv$
[*imaging0027.mcq*]

26. A population of 1000 people is tested for a disease. 800 receive a negative result. The prevalence of the disease is known to be 15%. What is the minimum value for the sensitivity of the test required to make the diagnostic accuracy at least 90%?

A. 0.833

B. 0.850

C. 0.912

D. 0.625

E. 0.800

Explanation: Setting up the contingency table with the given values, we have four equations with four unknowns.
$a + b + c + d = 1000$
$c + d = 800$
$a + c = 150$
$a + d = 900$

Solving, we get $a = 125$, $b = 75$, $c = 25$, and $d = 775$. We then calculate the sensitivity as $\frac{a}{a+c} = \frac{125}{150} = 0.833$.
[*imaging0028.mcq*]

27. You are visiting the doctor for a checkup. You have a routine test performed, and the result of the test is negative. You ask the doctor what it means to have a negative result: "Given that I have a negative test result, what is the chance that I actually don't have the disease?" Which term describes the value that the doctor is about to give you?

A. Negative predictive value

B. Positive predictive value

C. Specificity

D. Diagnostic accuracy

E. Prevalence

Explanation: Negative predictive value for a test describes the probability that a patient does not actually have the disease, given a negative test result.
[*imaging0029.mcq*]

28. The line spread function for a medical imaging system is given as
$l(x) = 4\cos(\alpha x)$ for $|x| \leq \frac{\pi}{20}$ and 0 otherwise. What is the resolution of this modality if $\alpha = 10$ radians/cm?

A. $\frac{15}{\pi}$ cm^{-1}
B. $\frac{30}{\pi}$ cm^{-1}
C. $\frac{\pi}{15}$ cm^{-1}
D. $\frac{\pi}{30}$ cm^{-1}
E. $\frac{3}{\pi}$ cm^{-1}

Explanation: This problem is based on homework #3, problem 3.7 from Prince. We know that the half-maximum of this function is 2, so $2 = 4\cos(10x_0)$, or $10x_0 = \frac{\pi}{3}$, giving $x_0 = \frac{\pi}{30}$. The FWHM is then twice x_0, or $\frac{\pi}{15}$. The resolution is the inverse of the FWHM, or $\frac{15}{\pi}$ cm^{-}1.
[*imaging0030.mcq*]

29. Which of the following statements is false?

A. The modulation transfer function of an imaging system is a model of the noise and artifacts present in the system.

B. The modulation transfer function of an imaging system characterizes the contrast in the system.

C. The modulation transfer function of an imaging system is the magnitude of the Fourier transform of the point spread function of that system normalized by the Fourier transform at DC.

D. The modulation transfer function of an imaging system can be used to quantify the resolution of that system.

E. The modulation transfer function of an imaging system can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

Explanation: MTF does not model the degradations of an imaging system – rather, it tells us about the resolution and contrast in the system.
[*imaging0031.mcq*]

30. Which of the following statements is false?

A. A smaller signal-to-noise ratio is one indication that the output of a medical imaging system is of high image quality.

B. Noise can be modeled using probability and random variables, making it possible to reduce the effect of noise.

C. Artifacts can occur as a result of poor image reconstruction techniques.

D. Artifacts degrade images in a repeatable or reproducible manner.

E. It is possible to remove some artifacts from images in an efficient and automated fashion.

Explanation: SNR is typically computed by taking the ratio of signal amplitude or power to that of the noise. A higher SNR indicates a better imaging system is in place. The other statements are true.
[*imaging0032.mcq*]

31. Which of the following imaging modalities is not one of the major modalities utilized in medical care in the United States?

A. Magneto Encephalography

B. Projection radiography

C. Magnetic resonance imaging

D. Ultrasound

E. Nuclear medicine

Explanation: Magneto Encephalography has yet to attain levels of use comparable to the other four imaging modalities shown here.
[*imaging0033.mcq*]

32. Which of the following statements is *false*?

A. In a sample of 10,000 coin tosses, the probability of getting exactly 4,900 heads is zero.

B. The uniform distribution describes equal probability across all values of a random variable.

C. In a sample of 10,000 people, the probability of someone having a height of exactly 5' 11" is zero.

D. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

E. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

Explanation: Continuous distributions cannot have nonzero probabilities associated with particular values, which is why we use density functions to calculate ranges of probabilities. Discrete distributions, however, do have nonzero probabilities associated with each discrete value.
[*imaging0034.mcq*]

33. Which of the following statements about image resolution is *false*?

A. Resolution is unrelated to the signal-to-noise ratio of an imaging system.

B. Resolution can be thought of as the ability of an imaging system to accurately depict two distinct events (in space, time, or frequency) as separate.

C. Resolution is related to the point spread function of an imaging system.

D. High resolution in an image is characterized by "low smearing."

E. Resolution is related to the modulation transfer function of an imaging system.

Explanation: Resolution, MTF, and PSF are all inter-related, and the SNR of a system is also related to its MTF. Thus, resolution is related to SNR as well.
[*imaging0035.mcq*]

34. Which of the following imaging modalities uses very strong magnetic fields?

A. MRI

B. CT

C. Ultrasound

D. PET

E. X-ray

Explanation: Only MRI uses very high field magnets.
[*imaging0058.mcq*]

35. A coronal slice

A. is parallel to the front of the body.

B. is parallel to the top of the head.

C. represents a projection through the side of the body.

D. divides the body into two roughly symmetrical halves.

E. can be at any orientation relative to the patient.

Explanation: The coronal plane parallel to the front of the body, like the corona behind the Christ figure's head in many medieval paintings.
[*imaging0059.mcq*]

36. The following are all true about tomographic images, *except*

A. They represent projections through the human body.

B. They can be coronal, sagittal, or axial.

C. Each pixel represents a localized sample in space.

D. They are called 'tomographic' because *tomos* is Greek for 'slice'.

E. Examples of tomographic image modalities includes MRI and CT.

Explanation: Tomographic images represent samples in space, rather than projections.
[*imaging0060.mcq*]

37. The Greek letter ξ is written in English as

A. xi

B. eta

C. phi

D. zeta

E. chi

Explanation: Although only used when most of the other letters are already taken, ξ is a full-fledged member of the Greek alphabet and deserves respect.
[*imaging0061.mcq*]

38. The following is (are) true about Signals and Systems as applied to imaging.

I - Where *time* is often the domain in conventional Signals and System, *distance* is often the domain in imaging.
II - Signals and Systems is usually applied in two or three dimensions in imaging.
III - The impulse function, convolution, and the Fourier transform are all commonly used in imaging.

A. I, II, and III

B. I and II

C. I and III

D. II only

E. None.

Explanation: Signals and Systems is central to many aspects of imaging, is applied in the spatial domain (as well as sometimes the temporal) domain, including the impulse function, convolution, and the Fourier transform, usually in two or three dimensions.
[*imaging0062.mcq*]

39. The following is (are) true about the impulse function in imaging:

I - It has an area of 1.
II - It can be used with integration to sample or "sift" another function.
III - It is infinitely high and infinitely narrow.

A. I, II, and III

B. I and II

C. I and III

D. II only

E. None.

Explanation: The impulse function has an area of 1, is infinitely high and infinitely narrow, and can be used to take a "snapshot" of another function by means of integration.
[*imaging0063.mcq*]

40. The following are true about complex exponentials (expressions of the form $e^{j\theta}$) *except*

A. They cannot represent a purely real number.

B. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

C. The represent a complex number on the unit circle in the complex plain centered on the origin.

D. They are central to Euler's identity.

E. They are used to represent sinusoids in a format that is amenable to algebraic manipulation.

Explanation: e^{j0} is a real number.
[*imaging0064.mcq*]

41. The Greek letter η is written in English as

A. eta

B. xi

C. phi

D. zeta

E. chi

Explanation: The Greek letter η (eta)may be used in the short poems, such as, "θ η potata."
[*imaging0065.mcq*]

42. A particular image consists of a sinusoidal variation in intensity along the x axis at a certain spatial frequency. Which of the following properties of that sinusoid may be changed by passing the image through a linear shift invariant system?

I - Amplitude.
II - Frequency.
III - Phase.

A. I and III.

B. I and II.

C. II and III.

D. I, II, and III.

E. I.

Explanation: For a linear shift invariant system, only the amplitude and phase of the sinusoid may change. The frequency must remain the same. Thus multiplication by the Fourier transform of the impulse response can define what the system does at each frequency independently.
[*imaging0066.mcq*]

43. The following are all true about the Fourier transform applied to images, *except*

A. A given image has a single Fourier transform, but a given Fourier transform may result from a number of different images.

B. The Modulation Transfer Function (MTF) of a linear shift invariant system is the Fourier transform of its impulse response (or Point Spread Function), normalized to the Fourier transform at the origin of the frequency domain.

C. Rotating an image results in rotating its Fourier transform.

D. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

E. The Fourier transform of the projection of an image onto its x axis is the u axis of the Fourier transform of the original image.

Explanation: Applying the Fourier transform to an image results (under ideal conditions) in no loss of information, and applying the inverse transform recreates the original image completely. It is thus a one-to-one mapping.
[*imaging0067.mcq*]

44. The following are all true about frequencies above half the sampling frequency, *except*

A. Their artifacts are generally avoided by removal in the discrete domain after sampling, rather than by filtering in the continuous domain before sampling.

B. They may be mistakenly interpreted as lower frequencies.

C. In images, they may appear as Moire patterns, or "beat frequencies".

D. The underlying discrete phasors may be viewed as a series of "snapshots" in which the phasors move further than 180 degrees between samples.

E. In the frequency domain, they may result in bleeding into the neighboring Nyquist Sampling Period.

Explanation: Once a frequency above half the sampling frequency is sampled, it is indistinguishable from the alias frequency. Filtering must be used to remove it in the continuous domain before sampling.
[*imaging0068.mcq*]

45. The following are all true about contrast, resolution, and noise in an imaging system *except*

A. Increased noise tends to lead to increased contrast and increased resolution.

B. They can be related to each other using mathematics that involves the Fourier transform.

C. They can each be quantified for an imaging system, although the method of quantification for each can be defined in various ways.

D. Each can be described as a function of frequency.

E. They can each effect the quality of an image and the accuracy of a diagnosis made from that image.

Explanation: Increased noise tends to lead to *decreased* contrast and *decreased* resolution.
[*imaging0069.mcq*]

46. Which of the following statements is *false* about discrete random variables?

A. A probability density function can describe the distribution of values.

B. A probability mass function can describe the distribution of values.

C. They can only assume integer values.

D. A probability distribution function can describe the distribution of values.

E. In physical system they are often described by a Poisson Distribution.

Explanation: Only a continuous random variables can have a probability density function.
[*imaging0070.mcq*]

47. The contingency table relates the results of a test to the presence of a disease, permitting the calculation of various quantities involving diagnostic accuracy, including all of the following, *except*

A. resolution

B. sensitivity

C. specificity

D. positive predictive value

E. prevalence

Explanation: Resolution is not a measure of accuracy, but rather a basic quality of the image itself.
[*imaging0071.mcq*]

48. Find the period of the following signal: $sin(6\pi x)cos(2\pi y)$

A. $T_x = \frac{1}{3}$, $T_y = 1$

B. $T_x = 3$, $T_y = 1$

C. $T_x = 6$, $T_y = 2$

D. $T_x = \frac{1}{2}$, $T_y = \frac{1}{2}$

E. $T_x = 1$, $T_y = 1$

Explanation: The period in the x and y directions are independent in this function, each belonging to its own sinusoid.
[*imaging0072.mcq*]

49. Given the signal $f(x, y) = x + y$: evaluate $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y)\delta(x - 1, y - 2)dxdy$

A. 3

B. $3\delta(x - 1, y - 2)$

C. $f(x - 1, y - 2)$

D. $f(x, y)$

E. $f(x + 1, y + 2)$

Explanation: The double integral performs "sifting" on $f(x, y)$ at location $(1, 2)$.
[*imaging0073.mcq*]

50. Given $\mathcal{F}[f(x,y)] = F(u,v)$ and $\mathcal{F}[g(x,y)] = G(u,v)$, find $\mathcal{F}[f(x,y) * g(x,y)]$

A. $F(u,v)G(u,v)$

B. $F(u,v) * G(u,v)$

C. $F(u,v) + G(u,v)$

D. $\frac{1}{|ab|}F(\frac{u}{a},\frac{v}{b}) * \frac{1}{|ab|}G(\frac{u}{a},\frac{v}{b})$

E. $F(u,v)G(u,v)e^{j2\pi(ux_0+vy_0)}$

Explanation: Convolution in the space domain is multiplication in the frequency domain.
[*imaging0074.mcq*]

51. If $f(x,y) = e^{j2\pi(4x+y)}$ find $\mathcal{F}[f(x,y)]$, given $\mathcal{F}[e^{j2\pi x u_0}] = \delta(u-u_0)$

A. $\delta(u-4, v-1)$

B. $\frac{1}{4}\delta(\frac{u}{4}, v)$

C. $\delta(u-5, v-5)$

D. $e^{j2\pi(4x+y)}$

E. $4e^{j2\pi(4x+y)}$

Explanation: Simple substitution, given $u_0 = 4$ and $v_0 = 1$.
[*imaging0075.mcq*]

52. $f(x)$ and $g(x)$ are band limited signals with Nyquist sampling frequencies of 250 Hz and 100 Hz respectively. Find the Nyquist sampling frequency for $f(x) + g(x)$.

A. 250 Hz

B. 100 Hz

C. 350 Hz

D. 200 Hz

E. 500 Hz

Explanation: The Nyquist sampling frequency is the minimum sampling frequency you required to avoide aliasing. In the combined signal, the Nyquist sampling frequency will be the higher of that for the two constituent signals.
[*imaging0076.mcq*]

53. If $\mathcal{F}[PSF] = \sqrt{5\pi}e^{-5\pi^2u^2}$ find the MTF. (*hint*: the Modulation Transfer Function (MTF) is the magnitude of the Fourier transform of the Point Spread Function (PSF), normalized by Fourier transform at 0 Hz.)

A. $e^{-5\pi^2u^2}$

B. $\sqrt{5\pi}$

C. $\sqrt{5\pi}e^{-5\pi^2u^2}$

D. $e^{\frac{x^2}{5}}$

E. $e^{5\pi^2u^2}$

Explanation: The Fourier transform at $u = 0$ Hz is $\sqrt{5\pi}$.
[*imaging0077.mcq*]

54. If $h(x) = e^{\frac{-x^2}{2}}$, find the FWHM (Full Width Half Maximum).

A. $2\sqrt{2ln(2)}$

B. $\sqrt{2ln(2)}$

C. $4\sqrt{2ln(\frac{1}{2})}$

D. $\sqrt{2ln(\frac{1}{2})}$

E. $2\sqrt{2ln(\frac{1}{2})}$

Explanation: This is a Gaussian, symmetrical around $x = 0$. It is even, and monotonic in both the positive and negative directions. Find $2x$ when $h(x) = \frac{1}{2}$, ($2x$ because the Full Width is from $-x$ to x).
[*imaging0078.mcq*]

55. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Diagnostic Accuracy.

A. 0.95

B. 0.67

C. 1.0

D. .10

E. .12

Explanation: Given

		disease	
		+	-
test	+	a	b
	-	c	d

Diagnostic Accuracy is $\frac{a+d}{a+b+c+d}$.
[*imaging0079.mcq*]

56. Consider the following continuous systems with input-output equations

I - $g(x, y) = f(x, y)^2$
II - $g(x, y) = 2f(x, y)$

Which system is (are) both linear and shift-invariant?

A. II

B. I

C. I and II

D. Neither of them

E. Cannot be determined

Explanation: A system is linear if, when the input consists of a collection of signals, the output is the summation of the responses of the system of each of those individual input signals. A system is shift-invariant if an arbitrary translation of the input signal results in an identical translation of the output.
[*imaging0080.mcq*]

57. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*

A. It always has the same spatial frequency in the x direction as in the y direction.

B. It has a magnitude of 1.

C. It forms an orthogonal basis set from which any image can be constructed.

D. It represents a cosine in the real domain and a sine in the imaginary domain.

E. It is a separable function.

Explanation: Its frequency in the x direction is u and in the y direction is v. It is not true that u always equals v.
[*imaging0081.mcq*]

58. In the discrete domain, the following is (are) true about the probability *mass* function.

I - It represents the derivative of the probability *distribution* function.
II - It is a histogram with an area of 1.
III - It can never be negative.

A. I, II, and III.

B. I and II.

C. II and III.

D. I and III.

E. None of them is true.

Explanation: All are true.
[*imaging0082.mcq*]

59. The axial plane

A. represents a tomographic slice orthogonal to the long axis of the body.

B. is parallel to the side of the body.

C. is parallel to the front of the body.

D. is parallel to the coronal plane.

E. is used only in projection radiography.

Explanation: The axial plane crosses the long axis of the body and is perpendicular to the other two planes (coronal and sagittal). It may be used in any 3D tomographic imaging modality, but not in projection radiography).
[*imaging0083.mcq*]

60. Which of the following statements is *false* about the modulation transfer function (MTF) of an imaging system?

A. It is always the same for any real imaging system.

B. It characterizes the contrast in the system.

C. It is the Fourier transform of the point spread function (PSF) of that system normalized to the Fourier transform at DC.

D. It can be used to quantify the resolution of that system.

E. It can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

Explanation: It MTF does not model the degradations of an imaging system – rather, it tells us about the resolution and contrast in the system.
[*imaging0084.mcq*]

61. Which of the following statements is false?

A. The Probability *Distribution* Function is only applicable to continuous variables.

B. The random variable associated with the current temperature at the North Pole is a continuous random variable.

C. In a sample of 100,000 people, the probability of someone having a height of exactly 5' 6" is zero.

D. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

E. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

Explanation: The Probability *Distribution* Function is used for both continuous and discrete variables.
[*imaging0085.mcq*]

62. The Greek letter ψ is written in English as

A. psi

B. eta

C. phi

D. zeta

E. chi

Explanation: ψ is sometimes used by psychologists and psychiatrists as shorthand to denote a psychiatric comment in the patient's records.
[*imaging0086.mcq*]

63. The following are all true about the Fourier transform applied to images, *except*

A. The Fourier transform of a real image function $f(x, y)$ consists of a function of frequency $F(u, v)$ that is always real, with no imaginary component.

B. Convolution in the spatial domain corresponds to multiplication in the frequency domain.

C. Rotating an image results in rotating its Fourier Transform.

D. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

E. Applying the Fourier transform to an image results (under ideal conditions) in no loss of information, and applying the inverse transform recreates the original image completely.

Explanation: The Fourier transform of a real image function can be (and usually is) complex, with the real component representing cosines and the imaginary component representing sines.
[*imaging0087.mcq*]

64. A particular image consists the function $Asin(ux + \theta)$. Which of the following properties of that sinusoid may be changed by passing the image through a linear shift invariant system?

I - A.
II - u.
III - θ.

A. I and III.

B. I and II.

C. II and III.

D. I, II, and III.

E. I.

Explanation: For a linear shift invariant system, only the amplitude and phase of the sinusoid may change. The frequency must remain the same. Thus multiplication by the Fourier transform of the impulse response can define what the system does at each frequency independently.
[*imaging0088.mcq*]

65. Given a continuous signal $f(x, y) = \frac{2x}{y^2}$, evaluate the following: $f(x, y)\delta(x + 1, y - 1)$

(Note that the impulse is not being integrated!)

A. $-2\delta(x + 1, y - 1)$

B. ∞

C. -2

D. $-\infty$

E. $\frac{2x}{y^2}$

Explanation: Since there is no integration happening, (this is not "sifting") the delta function remains in the answer.
[*imaging0089.mcq*]

66. The following is true of convolution, *except*

A. It can be used on signals in the temporal but not the spatial domains.

B. It requires the system to be linear to be meaningfully applied to the impulse response.

C. It exhibits the property of commutativity.

D. It exhibits the property of distributivity.

E. Convolution with the impulse function passes the other function through unchanged.

Explanation: Convolution applies to both the temporal and spatial domains.
[*imaging0090.mcq*]

67. The concept of Resolution can be used in which of the following domains?

I - Spatial
II - Temporal
III - Spectral (frequency)

A. I, II, and III.

B. I and II.

C. II and III.

D. I and III.

E. None of them is true.

Explanation: All are true.
[*imaging0091.mcq*]

68. The following is true about the Hankel Transform *except*.

A. It does not have an inverse transform.

B. It always relates a function of a single variable to another function of a single variable.

C. It requires circular symmetry.

D. It is the equivalent of the Fourier transform for functions where the spatial variable is radial distance.

E. It employs a Bessel function.

Explanation: The Hankel Transform, like the Fourier Transform, does have an inverse.
[*imaging0092.mcq*]

69. Which of the following imaging modalities uses radio frequency electromagnetic fields?

A. MRI

B. CT

C. Ultrasound

D. PET

E. X-ray

Explanation: Only MRI uses RF electromagnetic fields.
[*imaging0094.mcq*]

70. You go to the emergency room with a cough that produces bloody phlegm and a fever, and the doctor says that based on these symptoms you may have tuberculoses. You are alarmed and ask what are the odds of having tuberculoses as an inhabitant of this part of the world, irrespective on these particular symptoms. Which of the following are you requesting?

A. Prevalence

B. Sensitivity

C. Specificity

D. Diagnostic accuracy

E. Negative predictive value

Explanation: Prevalence describes what are the odds of having the disease, whether or not the test (symptoms in this case) is positive.
[*imaging0220.mcq*]

71. Which of the following statements is *false* about the modulation transfer function (MTF)?

A. The area under the MTF is always 1.

B. The MTF at zero frequency is always 1, and at infinite frequency it is always 0.

C. The MTF of an imaging system is the magnitude of the Fourier transform of the impulse response of that system normalized by the Fourier transform at DC.

D. The MTF of an imaging system can be used to quantify the resolution of that system.

E. The MTF represents the attenuation of a sinusoidal spatial pattern at a particular frequency.

Explanation: The area under the the probability density function (pdf) is always 1, not the MTF. The MTF always falls to 0 at infinite frequency, because no system can respond with infinite resolution.
[*imaging0221.mcq*]

72. The following are true about complex exponentials of the form $re^{j\theta}$ *except*

A. θ represents temporal or spatial frequency.

B. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

C. They can represent any complex number.

D. They are central to Euler's identity.

E. They are used to represent real sinusoids in a format that is amenable to algebraic manipulation, in which case a pair of complex conjugates must always be used.

Explanation: θ represents phase, not frequency.
[*imaging0222.mcq*]

73. The Greek letter ϕ is written in English as

A. phi

B. theta

C. psi

D. zeta

E. chi

Explanation: ϕ is sometimes pronounced 'fee' or 'fie' but never 'fo' or 'fum' ,
[*imaging0223.mcq*]

74. Which of the following imaging modalities uses ionizing radiation? (pick best answer)

A. Only CT

B. Ultrasound and MRI

C. Only MRI

D. MRI and CT

E. Only ultrasound

Explanation: CT uses X-Rays which are ionizing radiation, MRI uses magnetic fields and radio frequencies which are not ionizing (only frequencies at ultraviolet and above are ionizing). Ultrasound does not ionize tissue.
[*imaging0224.mcq*]

75. The following is *not* true about the impulse function, $\delta(x)$.

A. It can only be multiplied by a constant, and not by a variable function $f(x)$.

B. It is also known as the Dirac function.

C. $\delta(0) = \infty$.

D. It can be integrated and has an area of 1.

E. It can be translated to anywhere in the x domain.

Explanation: The impulse (delta, or Dirac) function is infinitely narrow, infinitely tall, with an area of 1. It is often shifted in the x domain and multiplied by a variable function to effect 'sifting'.
[*imaging0225.mcq*]

76. The following is true of a sagittal plane *except*

A. It is a projection through the body in the front-to-back direction.

B. It may be a mid-sagittal plane, dividing the body into two roughly symmetrical halves.

C. It represents a tomographic slice.

D. It is perpendicular to coronal planes.

E. It is perpendicular to axial planes.

Explanation: A sagittal plane is not a projection, but rather a tomographic slice.
[*imaging0226.mcq*]

77. The following is true of the Gaussian function of the form $\frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. It is always an even function.

B. Multiplication with another Gaussian having the same mean μ yields a Gaussian with the same mean.

C. Convolution with another Gaussian always yields a Gaussian whose standard deviation σ is at least as large as the larger of the two constituent's σ.

D. It approaches a constant function as σ approaches ∞.

E. It approaches an impulse function as σ approaches 0.

Explanation: It is only an even function when $\mu = 0$. As σ approaches ∞, it approaches 0, which is a constant function.
[*imaging0227.mcq*]

78. Which of the following statements about the point spread function (PSF) is *false*?

A. It is always circularly symmetric (rotationally invariant).

B. Resolution is limited by the PSF of a system.

C. It is sometimes characterized by the full width half maximum (FWHM), which for a Gaussian PSF is proportional to the standard deviation.

D. It fully defines a linear shift-invariant system.

E. If a group of systems are connected in series, the PSF of the group is determined by convolving the PSFs of the individual systems, and cannot be narrower than any of the constituent PSFs.

Explanation: The PSF does not have to be circularly symmetric, although for many systems it is assumed to be.
[*imaging0228.mcq*]

79. The following is true about the Poisson distribution

A. It is used to represent variation between samples of high-energy photons in an x-ray image, leading to Rose's model for SNR.

B. It involves a complex exponential.

C. It may be represented by a probability density function (pdf).

D. It may represent continuous or discrete random variables.

E. Its mean and standard deviation are equal.

Explanation: The Poisson distribution can only represent discrete variables. It's mean and *variance* are equal. It may only represent discrete random variables. It involves a *real* exponential.
[*imaging0229.mcq*]

80. Which of the following statements is *false* about the probability mass function (PMF) described by the equation, $\Pr[N = \eta_i]$, for $i = 1, 2, ..., k$?

A. Its integral is a probability density function (pdf).

B. It represents a histogram of the probabilities of a discrete random variable.

C. $\sum_{i=1}^{k} \Pr[N = \eta_i] = 1$

D. An example of a PMF is the Poisson distribution.

E. It may be used to describe how many heads or tails are expected in 1000 coin tosses.

Explanation: Since the PMF is for discrete random variables, it cannot be integrated (only summed) although it's sum up to a particular value is a probability distribution function (PDF).
[*imaging0230.mcq*]

81. Consider the following continuous systems with input-output equations. Which statement is true?

I - $g(x, y) = [f(x, y)]^2$
II - $g(x, y) = 3f(x, y) + 2$

A. Both systems are shift-invariant

B. Both systems are linear

C. System II is linear.

D. System I is linear.

E. System I is not shift invariant.

Explanation: A system is linear if, when the input consists of a collection of signals, the output is the summation of the responses of the system of each of those individual input signals. This is true for neither System I nor II. A system is shift-invariant if an arbitrary translation of the input signal results in an identical translation of the output. This is true for both System I and II.
[*imaging0231.mcq*]

82. Determine which of the following are periodic in both x and y.

I $\quad e^{j2\pi(ux+vy)} + e^{-j2\pi(ux+vy)}$, $u = 2, v = 3$

II $\quad \sum_{n=-\infty}^{\infty} \sum_{m=-\infty}^{\infty} \delta(x - n, y - m)$

III $\quad sinc(x)sinc(y)$

A. I and II

B. I

C. I and III

D. II and III

E. I, II, and III

Explanation: $sinc(x)sinc(y)$ is not periodic, although it does "ripple".
[*imaging0232.mcq*]

83. Given a continuous signal $f(x, y) = x^2 - 3y$, evaluate the following: $2f(x, y)\delta(x + 1, y - 3)$

(Note that the impulse is not being integrated!)

A. $-16\delta(x + 1, y - 3)$

B. $(x + 1)^2 - 3(y - 3)$

C. $-\infty$ for all x and y.

D. $2f(x, y)\delta(x^2, -3y)$

E. -16

Explanation: Since there is no integration happening, (this is not "sifting") the delta function remains in the answer, determining the only non-zero portion of the function.
[*imaging0233.mcq*]

84. For each system with the following impulse response, determine which one is stable.

I - $h(x, y) = e^{x^2+y^2}\delta(x, y)$
II - $h(x, y) = x^{-y}$

A. I

B. II

C. I and II

D. Neither I nor II

E. Cannot be determined

Explanation: Impulse response I is actually just $\delta(x, y)$ since it is zero everywhere except the origin, where $e^{x^2+y^2} = 1$; thus it is stable because it's integral over the (x, y) plane is finite. Impulse response II goes to ∞ for negative y and large x.
[*imaging0234.mcq*]

85. A physical examination was used to screen for breast cancer in 2,500 women with biopsy-proven adenocarcinoma of the breast and in 2,500 age- and race-matched control women without the disease. The results of the physical examination were positive in 1,800 of the women with known adenocarcinoma and in 800 control women who showed no evidence of cancer at biopsy. Find the *specificity* of the physical examination

A. 68%

B. 32%.

C. 70%.

D. 50%,

E. 28%,

Explanation: $((2500 - 800)/2500) * 100$
[*imaging0235.mcq*]

86. Which of the following statements about sampling is true?

A. Sampling artifacts consist of new frequencies not present in the original signal.

B. The Nyquist frequency is one-half of the highest frequency present in the signal.

C. The Nyquist frequency is twice the lowest frequency present in the signal.

D. The application of a filter to a continuous signal prior to sampling is needed to eliminate all frequencies lower than the sampling frequency.

E. Sampling artifacts may be removed after sampling, provided they are due to frequencies lower than Nyquist frequency.

Explanation: Continuous signals must be sampled in order to be stored and processed digitally. Signals should be sampled at a frequency greater than the signal's Nyquist frequency, which is twice the highest frequency present in that signal, to avoid aliasing of the signal (and subsequent loss of information). Filters are employed to get rid of high frequencies prior to sampling, not low frequencies. New aliased frequencies appear as the sampling artifact.
[*imaging0236.mcq*]

87. Which of the following properties of the Fourier Transform is incorrectly shown?

A. Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|} F\left(au, bv\right)$

B. Linearity: $F_{2D}(a_1 f + a_2 g)(u, v) = a_1 F(u, v) + a_2 G(u, v)$

C. Translation/Shifting: $F_{2D}(f(x - x_0, y - y_0))(u, v) = F(u, v) e^{-j2\pi(ux_0 + vy_0)}$

D. Parseval's Theorem: $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |f(x, y)|^2 dxdy = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |F(u, v)|^2 dudv$

E. Convolution: $F_{2D}(f * g)(u, v) = F(u, v) G(u, v)$

Explanation: All of the properties are correctly written except Scaling, which is incorrect in the Fourier Transform multiplying, rather than dividing, by the scaling term: Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$. Stretching in space means compressing in frequency (lower frequencies).
[*imaging0237.mcq*]

88. Which of the following statements is *false*?

A. White noise is a particular type of noise that is easy to remove after the fact because it is correlated between pixels.

B. Noise is often modeled using probability and random variables.

C. Artifacts are generally not due to random events but rather to unwanted but specific effects of the system.

D. Distortion is due to geometric effects and is thus often reversible.

E. Increasing the signal-to-noise ratio is one indication that the image quality in a system has been improved.

Explanation: White noise is completely uncorrelated, and thus the hardest kind of noise to remove.
[*imaging0238.mcq*]

89. Which of the following statements is *false*?

A. Resolution is limited by the lower frequencies in modulation transfer function of an imaging system.

B. Resolution can be thought of as the ability of an imaging system to accurately depict two distinct events (in space, time, or frequency) as separate.

C. Low resolution in an imaging system corresponds to a broad impulse response.

D. Even a high resolution imaging system is ultimately limited by the pixel spacing.

E. Resolution and the signal-to-noise ratio of an imaging system are positively correlated.

Explanation: The higher frequencies in the MTF limit the resolution.
[*imaging0239.mcq*]

90. The following is true of the Power Signal-to-Noise Ratio (SNR) *except*

A. The *signal* may vary in its power as a function of frequency, but *noise* always has the same power at all frequencies.

B. It is defined as the ratio of the power of the signal to the power of the noise.

C. It is often preferred to Amplitude SNR, because Power SNR is easier to compute as a function of frequency (Parseval's theorem).

D. A Noise Power Spectrum (NPS) may be measured for *signal* noise or for *system* noise.

E. The mathematics of Power SNR takes advantage of Parseval's Theorem

Explanation: White noise has the same power at all frequencies, but most (actually all) noise is not white (no noise has infinitely high frequencies in it).
[*imaging0240.mcq*]

91. Which of the following is your favorite part of the course so far? (Credit for all answers).

A. The Prince and Links book.

B. The metaphorical approach to the underlying mathematics.

C. The pictures from inside the human body.

D. The equations.

E. The amazing machines and physics.

Explanation: Any answer is considered correct.

Alternate acceptable answer: BCDE
[*imaging0241.mcq*]

92. The following is true about the sagittal plane, (or none is true)

A. None is true.

B. It is parallel to the top of the head.

C. It represents a projection through the side of the body.

D. It is parallel to the front of the body.

E. It is commonly acquired as an image using projection radiography.

Explanation: The sagittal plane is parallel to the side of the body but is not a projection. It may be used in any 3D tomographic imaging modality, but not in projection radiography).
[*imaging0280.mcq*]

93. The following are true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*, or all are true.

A. All are true.

B. Pairs of these complex exponentials in an image form sinusoidal variations at a particular orientation, frequency, amplitude, and phase, as determined by the Fourier transform $F(u, v)$ of that image.

C. It forms an orthogonal basis set from which any 2D image can be constructed.

D. It has an imaginary component, which can be cancelled by its complex conjugate.

E. It represents a complex number as a function of x and y

Explanation: The complex exponential does have an imaginary component, but complex conjugate pairs are added together to cancel that component.
[*imaging0281.mcq*]

94. The following is *not* true about sequential convolution with an image by a series of point spread functions (PSFs), or all are true.

A. All are true.

B. If one of the PSFs is much wider than all the others, the effective PSF of the entire process will be approximately the same width as that wider one.

C. The entire process can be described as multiplying the spectrum of the image by the product of the spectra of all the PSFs.

D. The entire process can be described as a single convolution with one combined PSF.

E. If the PSFs are Gaussians, the standard deviation of the effective PSF is exactly the Pythagorean sum of the standard deviations of the individual PSFs.

Explanation: Convolution in the spatial domain is equivalent to multiplication in the frequency domain. Both operations are associative (can be grouped).
[*imaging0282.mcq*]

95. Which of the following statements about sampling is true?

A. Sampling artifact is due to the fact that phasors, when sampled less frequently than two times per revolution, "appear" to spin at a different frequency and/or in a different direction.

B. The Nyquist frequency is one-half of the highest frequency present in the signal.

C. The Nyquist frequency is twice the lowest frequency present in the signal.

D. The application of a filter to a continuous signal prior to sampling is needed to eliminate the frequencies lower than the sampling frequency.

E. Sampling artifact is due to the fact that time is inherently not a continuous process, due to quantum effects.

Explanation: Continuous signals must be sampled in order to be stored and processed digitally. Signals should be sampled at a frequency greater than the signal's Nyquist frequency, which is twice the highest frequency present in that signal, to avoid aliasing of the signal (and subsequent loss of information). Filters are employed to get rid of high frequencies prior to sampling, not low frequencies. Answer E is silly.
[*imaging0283.mcq*]

96. A particular image consists the function $Asin(ux + \theta)$. Which of the following properties of that image will *not* be changed by passing it through a linear shift invariant system?

I - A.
II - u.
III - θ.

A. II

B. III

C. I, II, and III.

D. I and III.

E. I.

Explanation: For a linear shift invariant system, only the amplitude and phase of the sinusoid may change. The frequency must remain the same. Thus multiplication by the Fourier transform of the impulse response can define what the system does at each frequency independently.
[*imaging0284.mcq*]

97. In the continuous domain, all of the following are true about the probability *density* function (pdf) *except*, (or all are true)

A. All are true.

B. Its integral is the probability *distribution* function (PDF).

C. It always has an area of 1.

D. It can never be negative.

E. If the probability density function $p_N(\eta) \neq \infty$ then there is a zero probability of the exact value η.

Explanation: All are true.
[*imaging0285.mcq*]

98. The following are true about the Poisson distribution *except*, or all are true.

A. It has an area equal to the exponential constant, e, (approximately 2.718281828), because of the taylor series expansion.

B. It is used to represent variation between samples of relatively small numbers of randomly occurring discrete events, such as high-energy photons striking a particular detector.

C. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf), since it cannot represent a continuous variable.

D. All are true.

E. Its mean and variance are equal.

Explanation: It has an area equal to 1, as all PMFs have.
[*imaging0286.mcq*]

99. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Specificity.

A. 1.0

B. 0.67

C. 0.95

D. .10

E. .12

Explanation: Given

		disease	
		+	-
test	+	a	b
	-	c	d

Specificity is $\frac{d}{b+d}$.
[*imaging0287.mcq*]

100. Which of the following parameters of a phasor can be changed by a linear shift-invariant system?

A. phase and magnitude

B. magnitude and frequency

C. frequency and phase

D. phase, magnitude, and frequency

E. none of the other answers is correct

Explanation: Only magnitude and phase may be changed. Frequency must always stay the same, which is why phasors form an orthogonal basis set for linear shift-invariant (and time-invariant) systems.
[*imaging0305.mcq*]

101. The following are all true about the function $rect(x, y)$, *except*

A. It has circular symmetry.

B. $rect(x, y) = rect(x)rect(y)$.

C. It is seperable.

D. It is non-periodic.

E. $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} rect(x, y)dxdy = 1$

Explanation: Circular symmetry demands that $f_\theta(x, y) = f(x, y)$ for all θ, where f_θ denotes $f(x, y)$ rotated by θ. This is not true for the 2D rect function, which equals 1 within a square domain around the origin and 0 elsewhere.
[*imaging0306.mcq*]

102. If $h(x) = e^{-2x^2}$, find the FWHM (Full Width Half Maximum).

A. $\sqrt{2ln(2)}$

B. $2\sqrt{2ln(2)}$

C. $4\sqrt{2ln(\frac{1}{2})}$

D. $\sqrt{2ln(\frac{1}{2})}$

E. $2\sqrt{2ln(\frac{1}{2})}$

Explanation: This is a Gaussian, symmetrical around $x = 0$. It is even, and monotonic in both the positive and negative directions. Find $2x$ when $h(x) = \frac{1}{2}$, ($2x$ because the Full Width is from $-x$ to x).
[*imaging0307.mcq*]

103. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Sensitivity.

A. 0.67

B. 0.95

C. 1.0

D. .10

E. .12

Explanation: Given

		disease	
		+	-
test	+	a	b
	-	c	d

Sensitivity is $\frac{a}{a+c}$.
[*imaging0308.mcq*]

104. Which of the following statements is *true* about the modulation transfer function (MTF)?

A. The MTF of an imaging system is the magnitude of the Fourier transform of the impulse response of that system normalized by the Fourier transform at DC.

B. The MTF at zero frequency is always 0.

C. The area under the MTF is always 1.

D. The horizontal axis of the MTF is time.

E. The area under the MTF represents the attenuation of the average (grayscale) intensity of the image through the system.

Explanation: The MTF at zero frequency is always 1, not 0. The area under the the probability density function (pdf) is always 1, not the MTF. The horizontal axis of the MTF is frequency, not time. Answer E is baloney.
[*imaging0309.mcq*]

105. The Greek letter Υ is written in English as

A. upsilon

B. phi

C. psi

D. zeta

E. chi

Explanation: Υ, the capitol υ, is one of the more unusual greek letters, so if you need a new symbol that hasn't been used, keep Υ in mind.
[*imaging0310.mcq*]

106. The following is true of the Gaussian function of the form $\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. Convolution with another Gaussian having the same mean μ always yields a Gaussian with the same mean μ

B. Multiplication with another Gaussian yields a Gaussian whose standard deviation σ is smaller than either of the two constituents' σ.

C. The function forms a legitimate probability density function (pdf) for any finite value of μ and finite and positive value of σ.

D. It is an even function only when $\mu = 0$.

E. It approaches an impulse function as σ approaches 0.

Explanation: Convolution with another Gaussian having the same mean μ yields a Gaussian with twice the mean of the constituent Gaussians. Thus A is true only when $\mu = 0$.
[*imaging0311.mcq*]

107. Which of the following statements is *false* about the probability mass function (PMF) described by the equation, $\Pr[N = \eta_i]$, for $i = 1, 2, ..., k$?

A. The actual probability for any particular value of N is infinitely small.

B. It represents a histogram of the probabilities of a discrete random variable.

C. $\sum_{i=1}^{k} \Pr[N = \eta_i] = 1$

D. An example of a PMF is the Poisson distribution.

E. Although i is an integer, η_i does not need to be an integer, just a particular value for the discrete random variable N.

Explanation: The probability for a particular value of N can be finite, since it is a discrete random variable.
[*imaging0312.mcq*]

108. Given the signal $f(x, y) = x + y$: evaluate $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x, y)\delta(x + 1, y - 2)dxdy$

A. 1

B. $3\delta(x + 1, y - 2)$

C. $f(x + 1, y - 2)$

D. $f(x, y)$

E. 3

Explanation: The double integral performs "sifting" on $f(x, y)$ at location $(-1, 2)$.
[*imaging0313.mcq*]

109. Which of the following properties of the Fourier Transform is *incorrectly* shown?

A. Convolution: $F_{2D}(f * g)(u, v) = F(u, v) + G(u, v)$

B. Linearity: $F_{2D}(a_1 f + a_2 g)(u, v) = a_1 F(u, v) + a_2 G(u, v)$

C. Translation/Shifting: $F_{2D}(f(x - x_0, y - y_0))(u, v) = F(u, v)e^{-j2\pi(ux_0 + vy_0)}$

D. Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$

E. Parseval's Theorem: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |f(x, y)|^2 dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |F(u, v)|^2 dudv$

Explanation: All of the properties are correctly written except convolution, which, when performed in the spatial domain, results in multiplication in the frequency demain, or, $F_{2D}(f * g)(u, v) = F(u, v)G(u, v)$.
[*imaging0314.mcq*]

110. The following is *false* about the Fourier transform $F(u, v)$ of image $f(x, y)$, (or all are true).

A. All are true.

B. The Fourier transform of the projection of an image onto its x axis is a 1D function, equal to the value of the Fourier transform of the original image along its u axis.

C. Rotating an image results in rotating its Fourier Transform.

D. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

E. The average, or 'DC', value of the image $f(x, y)$ is a real number located at $F(0, 0)$

Explanation: All are true.
[*imaging0315.mcq*]

111. Which of the following statements about resolution is *false*?

A. The Full Width Half Maximum (FWHM) fully defines the resolution, without requiring any further knowledge about the Point Spread Function (PSF).

B. 'Spectral resolution' refers to the ability to distinguish one frequency from another, and is necessarily limited in the Fourier transform of a sampled image.

C. Spatial resolution is limited by the number of pixels or voxels per cm, but may also be further limited by the image acquisition or subsequent filtering.

D. Temporal resolution is limited by the number of images acquired per unit time.

E. Spatial resolution may be defined in terms of the Modulation Transfer Function (MTF), which, in practice, may be said to have a cut-off frequency, whose inverse is the resolution.

Explanation: The Full Width Half Maximum (FWHM) is an incomplete description of the resolution, since it depends on the particular shape of the Point Spread Function (PSF).
[*imaging0316.mcq*]

112. For a cascade of subsystems with Full Width Half Maxima (FWHM) of $R_1, R_2, R_3, \ldots, R_k$, with each subsystem having any possible Point Spread Function (PSF), which of the following statements is *false*, or all are true?

A. The total FWHM of the cascade will exactly equal the Pythagorean sum of the individual FWHMs, $R = \sqrt{{R_1}^2 + {R_2}^2 + {R_3}^2 + \ldots + {R_k}^2}$.

B. The system with the poorest resolution (largest R) dominates.

C. The PSF of the entire cascade will exactly equal the convolution of the individual PSFs with each other, in any particular order and grouped in any manner.

D. The FWHM of a Gaussian PSF is directly proportional to its standard deviation.

E. All are true.

Explanation: Answer A is only true for a Gaussian PSF, whose standard deviations will add when the Gaussians are convolved together.
[*imaging0317.mcq*]

113. Which of the following statements about random variables $N_1, N_2, N_3, \ldots, N_m$, whose probability density functions (pdf's) are $p_1(\eta), p_2(\eta), p_3(\eta), \ldots, p_m(\eta)$, is *false* about the sum of those random variables, N_S, or all are true?

A. The probability density function of N_S will be the product of the individual pdf's, $p_S(\eta) = p_1(\eta) \times p_2(\eta) \times p_3(\eta) \times \ldots \times p_m(\eta)$.

B. N_S will have a mean of $\mu_S = \mu_1 + \mu_2 + \mu_3 + \ldots + \mu_m$.

C. N_S will have a variance of $\sigma_S^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \ldots + \sigma_m^2$.

D. N_S will have a pdf whose area equals 1.

E. All are true.

Explanation: The probability density function of their sum will be the *convolution* of the individual pdf's, so that $p_S(\eta) = p_1(\eta) * p_2(\eta) * p_3(\eta) * \ldots * p_m(\eta)$. The area of any pdf equals 1, by definition.
[*imaging0318.mcq*]

114. Which of the following imaging modalities is not inherently tomographic?

A. Fluoroscopy

B. CT

C. Ultrasound

D. PET

E. MRI

Explanation: Fluoroscopy produces a projection rather than a tomographic image.
[*imaging0319.mcq*]

115. The following is true statements about decibels *except*

A. They are often used as the unit for Signal to Noise Ratio (SNR), where, if the noise has a Poisson distribution, the mean μ represents the noise and the standard deviation σ represents the signal.

B. They are named in honor of the inventor of the telephone.

C. They provide a scale whose dynamic range better matches that of human perception (e.g. of sound and light) than would a linear scale.

D. If the amplitudes of two signals, A and B, are V_A and V_B, respectively, the number of decibels increasing from A and B is $20 \times log_{10} \frac{V_B}{V_A}$.

E. Decibels, denoted as 'dB', represent a pure fraction without dimension.

Explanation: In noise with a Poisson distribution, the mean μ represents the *signal* and the standard deviation σ represents the *noise*.
[*imaging0320.mcq*]

116. You go to the emergency room with a cough that produces bloody phlegm and a fever, and the doctor says that based on these symptoms you may have tuberculoses (TB). You are alarmed and ask how likely it is to have TB, given those symptoms. Which of the following are you requesting?

A. Positive predictive value

B. Specificity

C. Sensitivity

D. Diagnostic accuracy

E. Prevalence

Explanation: Positive predictive value describes what are the odds of having the disease, given that a test (symptoms in this case) is positive. The symptoms could mean you have some other disease, like the flu. Specificity is the likelihood of not having symptoms if you don't have the the disease, in other words TB always comes with a bloody cough. This is a different question that what you were asking.
[*imaging0321.mcq*]

117. The following are true about complex exponentials of the form $re^{j\theta}$ *except*

A. They can represent any complex number except 0, because $re^{j0} = 1$

B. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

C. θ may represent temporal or spatial phase.

D. When multiplied together, they scale each other's magnitudes and rotate each other's phase.

E. They can be used to represent real sinusoids in a format that is amenable to algebraic manipulation, by using complex conjugates to eliminate the imaginary component.

Explanation: Answer A is not true, since if $r = 0$, $re^{j\theta} = 0$
[*imaging0322.mcq*]

118. Which of the following statements about the point spread function (PSF) is *false*?

A. The PSF is the Fourier Transform of the impulse response.

B. Resolution is limited by the PSF of a system.

C. If it is circularly symmetric, then the Modulation Transfer Function (MTF) is rotationally invariant.

D. It fully defines a linear shift invariant system.

E. If the PSF is a delta function with area 1, then the system does not change the signal passing through it.

Explanation: The PSF is the impulse response itself, not its Fourier Transform.
[*imaging0323.mcq*]

119. The following is true of the Power Signal-to-Noise Ratio (SNR) *except*, or all are true.

A. All are true.

B. It is defined as the ratio of the power of the signal to the power of the noise.

C. It is often preferred to Amplitude SNR, because Power SNR is easier to express as a function of frequency, by using Parseval's Theorem.

D. The *signal* and *noise* may each vary in their power as a function of frequency.

E. For white noise, the power of the *noise* is constant with frequency.

Explanation: All are true
[*imaging0324.mcq*]

120. The following are true about Receiver Operator Characteristic (ROC) curves *except* (or all are true):

A. They express the precision of a test but not the accuracy.

B. They represent a plot of sensitivity vs. (1-specificity) over a range of thresholds.

C. The plot always proceeds from (0,0) and ends at (1,1).

D. A test that produces random results has an area under the curve of 1/2.

E. All are true.

Explanation: The ROC is an expression of the accuracy of a test, because it is assumed that the ground truth (i.e., whether the disease is present) is knowable.
[*imaging0389.mcq*]

121. Which of the following is *false* about the Mass Spectrometer, (or all are true):

A. All are true.

B. It accelerates ions using a large electrostatic field.

C. It bends the paths of ions using a magnetic field.

D. It separates isotopes by differences in mass.

E. It can differentiate between the numbers of neutrons in atoms with the same atomic number.

Explanation:
[*imaging0390.mcq*]

122. An impulse response $h(x, y)$ is represented by the function

$$h(x,y) = \begin{cases} 1-\sqrt{x^2+y^2}, & x^2+y^2<1 \\ 0, & \text{otherwise} \end{cases}$$

The following are true *except* (or all are true):

A. All are true.

B. The Modulation Transfer Function (MTF) of this function is the Fourier transform $H(u, v)$ of $h(x, y)$ normalized by $H(0, 0)$.

C. The impulse response has circular symmetry

D. The Fourier transform $H(u, v)$ of $h(x, y)$ has circular symmetry.

E. The full width half-maximum is equal to 1.0.

Explanation:
[*imaging0391.mcq*]

123. The following is true of the Gaussian probability density function (pdf), $p_N(\eta) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(\eta-\mu)^2}{2\sigma^2}}$ *except* (or all are true).

A. The standard deviation of a population with this pdf is σ^2.

B. Its integral is a Probability Distribution Function (PDF) which contains a particular function commonly called "the error function"

C. The area under $p_N(\eta)$ is always 1.

D. The "expected" value $E[N] = \mu$, no matter what the value of σ.

E. All are true.

Explanation: The standard deviation of a population with this pdf is σ. Its square, σ^2, is the *variance*.
[*imaging0392.mcq*]

124. The following are true about sequential convolution with an image by a series of point spread functions (PSFs) *except* (or all are true).

A. All are true.

B. The PSF for the entire process is always wider (worse resolution) than for any of the contributing PSFs.

C. The entire process can be described as multiplying the Fourier transform of the image by the product of the Fourier transforms of all the PSFs.

D. The entire process can be described as a single convolution with one combined PSF.

E. If the PSFs are Gaussians, the standard deviation of the effective PSF is exactly the Pythagorean sum of the standard deviations of the individual PSFs.

Explanation:
[*imaging0393.mcq*]

125. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0x+v_0y)}$, *except*, (or all are true).

A. All are true.

B. Complex conjugate pairs of these complex exponentials form real sinusoidal variations at particular orientations and frequency in space.

C. It is always real at the origin (x, y), no matter what the frequencies (u_0, v_0) are.

D. It can be scaled and shifted in phase by multiplication with a complex number, but not changed in frequency.

E. Its maximum spatial frequency is in the (u_0, v_0) direction.

Explanation: It is always real at the origin (x, y), because its real part is a cosine and imaginary part is a sine. To take on other phases in building $f(x, y)$, it must be multiplied by a complex number, the Fourier transform $F(u, v)$.
[*imaging0394.mcq*]

126. The following are true about the Poisson distribution $Pr[N = k] = \frac{a^k}{k!}e^{-a}$, where a is a constant, *except* (or all are true).

A. The probability that $k = 0$ is always zero.

B. It is used to represent variation between samples of relatively few events, such as the number of high energy photons hitting a detector per unit time.

C. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf)

D. All are true.

E. Its mean and variance are equal.

Explanation: For large values of a the probability that $k = 0$ approaches but does not reach zero. For smaller a (fewer average events), the likelihood that zero events occurred can become quite high.
[*imaging0395.mcq*]

127. Consider the following continuous systems whose outputs $g(x, y)$ are related to their inputs $f(x, y)$ as follows:

I - $g(x, y) = 2 - f(x, y)$
II - $g(x, y) = [f(x, y)]^2$

Which system is (are) both linear and shift-invariant?

A. Neither of them

B. II

C. Both I and II

D. I

E. Cannot be determined from the information given.

Explanation: A system is linear if, when the input consists of a collection of signals, the output is the summation of the responses of the system of each of those individual input signals. A system is shift-invariant if an arbitrary translation of the input signal results in an identical translation of the output. Both I and II are shift invariant, but neither are linear. I is not linear because $g(x, y)$ does not equal zero when $f(x, y) = 0$
[*imaging0396.mcq*]

128. Which of the following properties of the Fourier Transform is incorrectly shown?

A. Translation/Shifting: $F_{2D}(f(x-x_0, y-y_0))(u,v) = F(u-u_0, v-v_0)$

B. Linearity: $F_{2D}(a_1 f + a_2 g)(u,v) = a_1 F(u,v) + a_2 G(u,v)$

C. Parseval's Theorem: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |f(x,y)|^2 dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |F(u,v)|^2 dudv$

D. Scaling: $F_{2D}(f(ax,by))(u,v) = \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$

E. Convolution: $F_{2D}(f * g)(u,v) = F(u,v)G(u,v)$

Explanation: All of the properties are correctly written except Translation/Shifting, which should be $F_{2D}(f(x-x_0, y-y_0))(u,v) = F(u,v)e^{-j2\pi(ux_0+vy_0)}$. Translation in (x,y) results in phase shifts proportional to frequency.
[*imaging0397.mcq*]

129. The following are all true about the Fourier transform applied to images, *except*

A. A given image has a single Fourier transform, but a given Fourier transform may result from a number of different images.

B. The Modulation Transfer Function (MTF) of a linear shift invariant system is the Fourier transform of its impulse response (or Point Spread Function), normalized to the Fourier transform at the origin of the frequency domain.

C. Rotating an image results in rotating its Fourier transform.

D. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

E. The Fourier transform of the projection of an image onto its x axis is the u axis of the Fourier transform of the original image.

Explanation: Applying the Fourier transform to an image results (under ideal conditions) in no loss of information, and applying the inverse transform recreates the original image completely. It is thus a one-to-one mapping.
[*imaging0398.mcq*]

130. The following are all true about frequencies above half the sampling frequency, *except*

A. Artifacts may be avoided by inclusion of the complex conjugate phasor at the corresponding negative frequency.

B. They may be mistakenly interpreted as lower frequencies.

C. In images, they may appear as Moire patterns, or "beat frequencies".

D. The underlying discrete phasors may be viewed as a series of "snapshots" in which the phasors move further than 180 degrees between samples.

E. Their artifacts can only be avoided by guaranteeing no frequency components above half the sampling frequency are present in the continuous domain *before* sampling.

Explanation: Real sinusoids all contain both complex conjugate phasors, whether or not they are above half the sampling frequency. This does not avoid sampling artifact.
[*imaging0399.mcq*]

131. Given the signal $f(x,y) = x^2 - y$: evaluate $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(x+3,y-1)dxdy$

A. 8

B. $8\delta(x+3,y-1)$

C. $f(x+3,y-1)$

D. $\delta(x+3,y-1)$

E. Cannot be evaluated since $f(x,y)$ is not linear.

Explanation: The double integral performs "sifting" on $f(x,y)$, evaluating the function at location $(-3,1)$. The expression $f(x+3,y-1)$ is simply a shifted version of $f(x,y)$. Sifting does not require the function to be linear.
[*imaging0400.mcq*]

132. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Specificity.

A. 1.00

B. 0.5

C. 0.95

D. .66

E. ∞

Explanation: Given

		disease	
		+	-
test	+	a	b
	-	c	d

Specificity is $\frac{d}{b+d}$. This test never gives a false positive!
[*imaging0401.mcq*]

133. The following is (are) true about the probability *mass* function.

I - It is the integral of the Probability Distribution Function (PDF)
II - It can only be used for discrete random variables.
III - It can never be negative.

A. II and III.

B. I and II.

C. I, II, and III.

D. I and III.

E. III

Explanation: The Probability Distribution Function (PDF) is the integral of *it*.
[*imaging0402.mcq*]

134. Which of the following statements about the point spread function (PSF) is *false*?

A. It is the Fourier transform of the response to the impulse function.

B. Resolution is limited by the PSF of a system.

C. It is sometimes characterized by the full width half maximum (FWHM), which for a Gaussian PSF is proportional to the standard deviation.

D. It fully defines a linear shift-invariant system.

E. It can be circularly symmetric (rotationally invariant), but does not have to be.

Explanation: Answer A is nonsense. The PSF *is* the impulse function.
[*imaging0403.mcq*]

135. For a cascade of subsystems with Full Width Half Maxima (FWHM) of $R_1, R_2, R_3, \ldots, R_k$, with each subsystem having its own Point Spread Function (PSF), which of the following statements is *false*, or all are true?

A. All are true.

B. The system with the poorest resolution (largest R) dominates.

C. The PSF of the entire cascade will exactly equal the convolution of the individual PSFs with each other, in any particular order and grouped in any manner.

D. The FWHM of a Gaussian PSF is directly proportional to its standard deviation.

E. For Gaussian PSFs, the total FWHM of the cascade will exactly equal the Pythagorean sum of the individual FWHMs, $R = \sqrt{{R_1}^2 + {R_2}^2 + {R_3}^2 + \ldots + {R_k}^2}$.

Explanation:
[*imaging0404.mcq*]

136. The following are true about complex exponentials of the form $re^{j\theta}$ *except* (or all are true).

A. All are true.

B. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

C. In a 1-dimensional signal vs. time, θ may be replaced with ωt (rotational frequency $\times$ time).

D. When multiplied together, they scale each other's magnitudes and rotate (add) each other's phase.

E. They are used to represent real sinusoids in a format that is amenable to algebraic manipulation, in which case a pair of complex conjugates must always be present.

Explanation:
[*imaging0405.mcq*]

137. Which of the following statements is *incorrect*?

A. The Hankel transform of the *rect* function is a *sinc* function.

B. Both *sinc(x)* and *jinc(x)* have defined finite values when x = 0.

C. Given the convolution $f(x, y) * g(x, y)$ in spatial domain, its Fourier transform will be $F(u, v)G(u, v)$ in frequency domain.

D. The scaling property of the Fourier transform can be written as $F_{2D}(f(ax, by)) = \frac{1}{|ab|} F(\frac{u}{a}, \frac{v}{b})$.

E. If $f(x, y)$ is rotated by an angle θ, then its Fourier transform is rotated by angle θ as well

Explanation: The hankel transform of the *rect* function is a *jinc* function.
[*imaging0437.mcq*]

138. Which of the following is *true* about image quality?

A. The MTF quantifies degradation of contrast as a function of spatial frequency. So for most medical imaging systems for every u, we have $0 \leq MTF(u) \leq MTF(0) = 1$.

B. The difference between the target and its background is captured by the *local contrast*, defined as $C = \frac{f_t}{f_b}$.

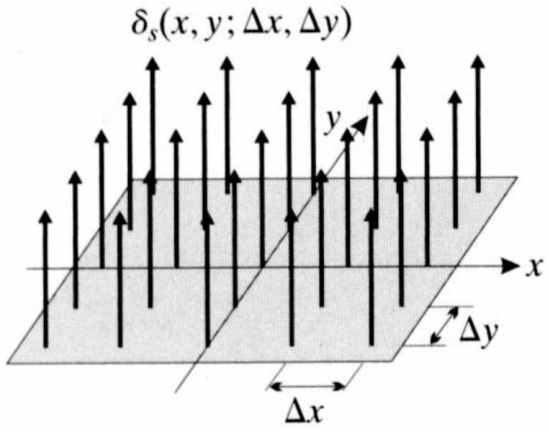
C. Given a cascade LSI system, if the FWHM of its subsystems have the relationship $R_1 > R_2 > R_3$, the resolution of the overall system is dominated by subsystem R_3.

D. The Signal to Noise Ratio (SNR) is often computed as a ratio where the mean μ represents the noise and the standard deviation σ represents the signal.

E. All are true.

Explanation: The difference between the target and its background is captured by the *local contrast*, defined as $C = \frac{f_t - f_b}{f_b}$. The resolution of the overall system is dominated by resolution R_1 corresponding to the largest FWHM, i.e., poorest resolution. The mean μ represents the signal and the standard deviation σ represents the noise.
[*imaging0442.mcq*]

139. Which of the following is *false* about the mathematical function shown below (or all of the others are true)?



A. All of the others are true.

B. Its Fourier transform is another such function.

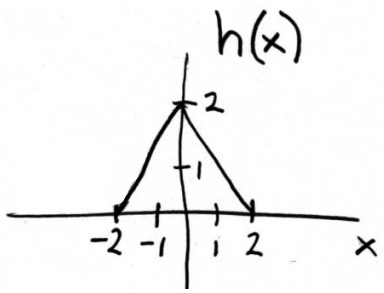
C. It is used to sample continuous data in the spatial domain (by means of multiplication in the spatial domain).

D. Its Fourier transform accounts for repetition in the frequency domain (by means of convolution in the frequency domain) when continuous data in the spatial domain is sampled.

E. It is generally represented mathematically as the sum of a set of displaced impulse functions.

Explanation: The sampling function, which is a comb function spaced with physical dimensions, is a set of impulse functions, usually expressed as the sum of displaced impulse functions since they are orthogonal and don't affect each other. It's Fourier transform is another sampling function, which accounts for the repetition of the frequency domain when a continuous spatial function is sampled.
[*imaging0445.mcq*]

140. What is the Full Width Half Maximum (FWHM) of the following impulse response (one-dimensional Point Spread Function)?



A. 2

B. 1

C. 4

D. 0.5

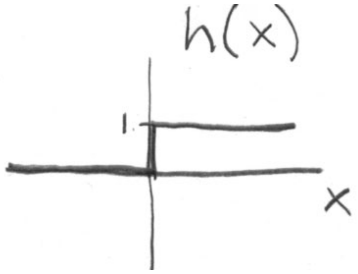
E. None of the other answers is correct

Explanation: The FWHM is the width of $h(x)$ at half of its maximum value.

Alternate acceptable answer: E

Errata: The drawing is a little off, and some students said none of the answers were correct.
[*imaging0462.mcq*]

141. Assuming $g(x) = f(x) * h(x)$, for the $h(x)$ shown below, which of the following is true?



A. $g(x) = \int_{-\infty}^{x} f(\xi) d\xi$.

B. $g(x) = f(x)$

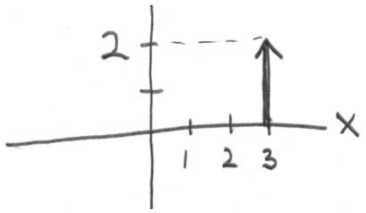
C. $g(x) = \frac{df(x)}{dx}$

D. $g(x) = f(x)h(x)$

E. None of the other answers is correct

Explanation: Convolution with the unit step function is equivalent to integration. As you flip $h(x)$ around and slide it past $f(x)$, multiplying the two and integrating, you get the integral of $f(x)$ from $-\infty$ to wherever you have slid it to.
[*imaging0463.mcq*]

142. Assuming $g(x) = f(x) * h(x)$, for the $h(x)$ shown below, which of the following is true?



A. $g(x) = 2f(x - 3)$.

B. $g(x) = 2f(x + 3)$

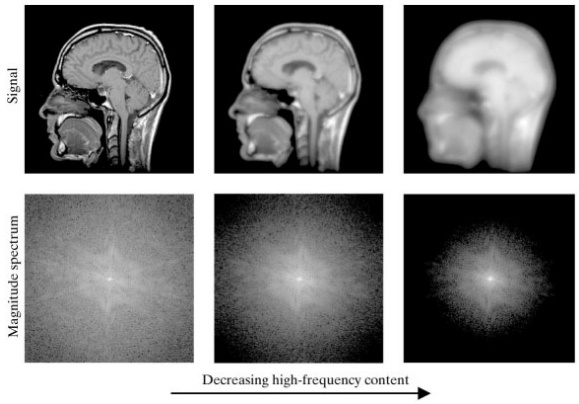
C. $g(x) = 3 - f(2x)$

D. $g(x) = 6f(x)$

E. None of the other answers is correct

Explanation: Convolution with the displaced and scaled impulse function results in an equally displaced and scaled output.
[*imaging0464.mcq*]

143. Given the images below and their corresponding Fourier transforms, showing an original scan followed by convolution with a 2D Gaussian, which of the following statements is *false* (or all are true)?



A. All are true.

B. The Fourier transforms (from left to right) show decreasing magnitudes in the high frequencies, which are furthest from the center of each transform as shown.

C. For each of the Fourier magnitude transforms, there is a corresponding phase transform that is not shown.

D. A given location in each Fourier transform represents a phasor with a particular horizontal and vertical frequency component.

E. The original image (upper left) is a sagittal slice through a human head.

Explanation:
[*imaging0465.mcq*]

144. Given the following function, which of the following statements is *false*?

$f(x,y) = \frac{e^{j2\pi(x+y)}+e^{-j2\pi(x+y)}}{2}$

A. The value of $f(x,y)$ approaches infinity exponentially.

B. $f(0,0)$=1.

C. $f(x,y)$ varies sinusoidally along a direction described by the vector (1,1) in the (x,y) plane.

D. $f(x,y)$ has a real value for all x and y because it consists of two phasors that are complex conjugates of each other.

E. $f(x,y)$ is periodic.

Explanation: The value of $f(x,y)$ is bounded by 1 and -1.
[*imaging0466.mcq*]

145. The equation,

$F(u,v) = |F(u,v)|e^{j\angle F(u,v)}$,

demonstrates the following attributes of the Fourier transform, $F(u,v)$, *except* (or all are true).

A. $F(u,v)$ is a phasor that varies (rotates) as a function of space (x and y).

B. $F(u,v)$ is a complex number.

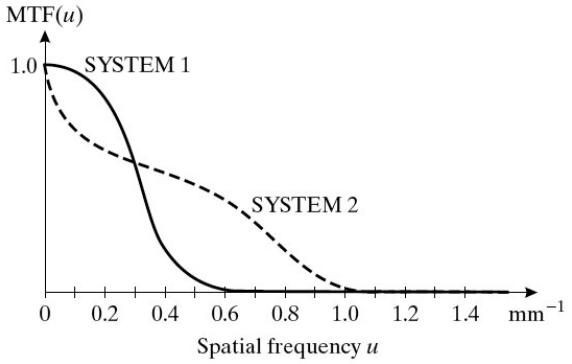
C. $F(u,v)$ consists of a magnitude and a phase.

D. $|F(u,v)|$ is a real number, while $e^{j\angle F(u,v)}$ is a complex number with a magnitude of 1.

E. All are true.

Explanation: $F(u,v)$ is indeed a phasor, but it does not vary as a function of x and y. Rather, it sets the magnitude and starting phase of the phasor $e^{j2\pi(ux+vy)}$
[*imaging0467.mcq*]

146. Given the figure shown below, which of the following statements is *true* (or none is true)?



A. Resolution cannot always be expressed by a single value.

B. System 1 has a superior resolution to System 2.

C. System 2 has a superior resolution to System 1.

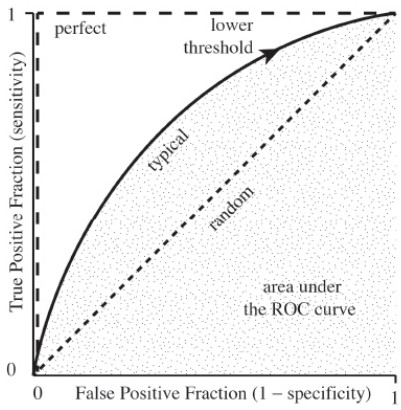
D. Both System 1 and System 2 represent, in frequency domain, Gaussian Point Spread Functions (PSFs) in the spatial domain.

E. None of the other answers is true.

Explanation: A Gaussian PSF would also have a Gaussian MTF. System 2 is not shaped like a Gaussian. Resolution is a function of frequency, and cannot generally be fully expressed by a single number, except in special cases, such as the Gaussian (which these are not).
[*imaging0468.mcq*]

147. Assuming the area under an ROC curve is 1 for a given diagnostic test for a certain disease, which of the following statements about the test is *true* (or all are false)?

Receiver Operator Characteristics (ROC) Curve



A. The sensitivity and the specificity are both equal to 1.

B. The prevalence of the disease is zero.

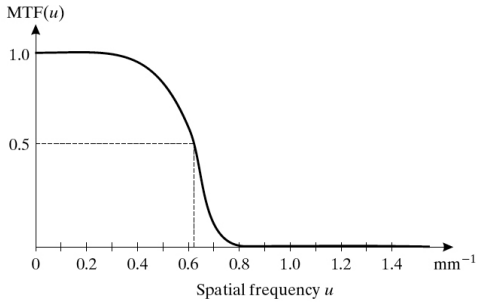
C. There may be many false negatives, but no false positives.

D. The diagnostic test is worthless.

E. All are false.

Explanation: This is a perfect diagnostic test, totally sensitive and specific. Nothing can be said about the prevalence from the ROC curve. There will be no false negatives or false positives.
[*imaging0495.mcq*]

148. Given the following isotropic Modulation Transfer Function (MTF) for an imaging system, which of the following statements is *false* (or all are true)?



A. This MTF implies that the Point Spread Function (PSF) must be an impulse function.

B. This MTF is the Fourier transform of a 1D cross-section of the Point Spread Function (PSF) normalized to 1.0 at spatial frequency 0.

C. The Full Width Half Maximum (FWHM) is approximately 2×0.62 cycles/mm.

D. The attenuation of the system increases monotonically with spatial frequency.

E. All are true.

Explanation: If the PSF were an impulse function, the MTF would be a constant of 1 all the way up to a spatial frequency of infinity, which is not true of this MTF (or any real system).
[*imaging0496.mcq*]

149. Given the following function, which of the following statements is *false*, (or all are true)?

$f(x,y) = \frac{e^{j2\pi(x+y)} + e^{-j2\pi(x+y)}}{2}$

A. $f(x,y)$ is periodic with a period of 2, in the direction of its minimum period.

B. All are true.

C. $f(x,y)$ varies sinusoidally along a direction described by the vector (1,1) in the (x,y) plane.

D. $f(x,y)$ has a real value for all x and y because it consists of two phasors that are complex conjugates of each other.

E. The value of $f(x,y)$ has a maximum value of 1.

Explanation: $f(x,y)$ is periodic with a period of $\sqrt{2}$, in the direction of its minimum period, along the vector (1,1).
[*imaging0497.mcq*]