BioE 1330 - Review Intro and Chapters 1, 2, and 3 1/17/2011

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 does not use ionizing radiation? (pick best answer)

A. Only MRI

B. Ultrasound and CT

C. Ultrasound and MRI

D. Only ultrasound

E. Only CT

2. The mid-sagittal plane

A. is parallel to the front of the body.

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

C. is only used in CT but not MRI.

D. is parallel to the top of the head.

E. divides the body into two roughly symmetrical halves.

3. The sagittal plane

A. is used only in projection radiography.

B. is parallel to the front of the body.

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

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 is also known as the Dirac function.

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

C. It cannot be integrated.

D. It is infinitely narrow.

E. It has an area of 1.

5. Computerized Tomography (CT)

A. requires the use of radioactive isotopes.

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

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

D. requires extremely strong magnetic fields.

E. depends on multiple projections of X-rays from many angular orientations to compute a slice 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. It approaches an impulse function when σ approaches 0.

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

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

D. 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.

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

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

A. It exhibits the property of associativity.

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

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

D. It exhibits the property of commutativity.

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

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

A. It is a periodic function.

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

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

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

E. Complex conjugate pairs of these complex exponentials form sinusoidal variations at particular orientations, frequency, amplitude, and phase, as determined by the Fourier transform $F(u, v)$.

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 III.

B. II and III.

C. I.

D. I and II.

E. I, II, 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 $\frac{1}{2}$ when there is no contrast in the image.

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

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

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

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

12. The following is *not* true about sequential convolution with an image by a series of point spread functions (PSFs)

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. The effective PSF for the entire process may be narrower than one or more of the contributing PSFs.

C. 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.

D. 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.

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

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

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

A. None of them is true.

B. I and II.

C. I, II, and III.

D. II and III.

E. I and III.

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

A. It can model randomly occurring discrete events.

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

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

D. Its mean and variance are equal.

E. It may represent continuous or discrete random variables.

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

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. Cannot be determined

C. I and II

D. Neither of them

E. II

16. Determine which of the following signals are separable.

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

A. I and III

B. I, II, and III

C. I

D. I and II

E. II

17. 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 and III

C. I and II

D. I, II, and III

E. II

18. 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. $x + y^2$

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

C. 3

D. 5

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

19. 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. I

C. Cannot be determined

D. I and II

E. II

20. Please 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 and depict two signals that differ in space, time, or energy as distict.
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 - 3 , b - 4 , 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 - 4, b - 3, c - 5, d - 2, e - 1

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

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

A. Integrates Bioengineering, Biology, and Medicine.

B. All of the other statements.

C. Requires training in computational and life sciences.

D. Is a multidisciplinary area.

E. Can be used for Diagnosis and Therapy.

22. 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 images bone differently from soft tissue whereas MRI does not.

B. CT differentiates heavy from light atoms while MRI differentiates the local environments of hydrogen atoms.

C. None of the other statements is true.

D. MRI uses ionizing radiation whereas CT does not.

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

23. Which of the following statements is true?

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

B. None of the other statements is true.

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

D. PET and MRI are examples of emission imaging.

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

24. 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. 69.2

B. 72.0

C. 28.0

D. 84.0

E. 36.0

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

D. The Nyquist frequency is twice the lowest 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.

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

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

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: $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |f(x, y)|dxdy = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |F(u, v)|dudv$

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

27. 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. 0.850

B. 0.625

C. 0.912

D. 0.833

E. 0.800

28. 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. Prevalence

B. Diagnostic accuracy

C. Specificity

D. Negative predictive value

E. Positive predictive value

29. 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. $\frac{\pi}{30}$ cm^{-1}

C. $\frac{30}{\pi}$ cm^{-1}

D. $\frac{3}{\pi}$ cm^{-1}

E. $\frac{\pi}{15}$ cm^{-1}

30. Which of the following statements is false?

A. 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.

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 characterizes the contrast in the system.

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 is the magnitude of the Fourier transform of the point spread function of that system normalized by the Fourier transform at DC.

31. Which of the following statements is false?

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

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

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

32. As of 2008, which of the following imaging modalities is not one of the major modalities utilized in medical care in the United States?

A. Projection radiography

B. Magnetic resonance imaging

C. Magneto Encephalography

D. Nuclear medicine

E. Ultrasound

33. 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 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.

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

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

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

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

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

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

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

A. Ultrasound

B. X-ray

C. MRI

D. PET

E. CT

36. A coronal slice

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

B. is parallel to the front of the body.

C. is parallel to the top of the head.

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

E. divides the body into two roughly symmetrical halves.

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

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

B. They represent projections through the human body.

C. Each pixel represents a localized sample in space.

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

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

38. The Greek letter ξ is written in English as

A. phi

B. eta

C. xi

D. zeta

E. chi

39. 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 and II

B. II only

C. I, II, and III

D. I and III

E. None.

40. 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. None.

C. I and III

D. I and II

E. II only

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

A. They cannot represent a purely real number, because real numbers cannot be raised to an imaginary power.

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

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

D. They are central to Euler's identity.

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

42. The Greek letter η is written in English as

A. chi

B. zeta

C. eta

D. xi

E. phi

43. 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. I.

E. II and III.

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

A. The "Transfer Function" of a linear shift invariant system is the Fourier transform of its impulse response (or Point Spread Function).

B. The Fourier transform of the projection of an image onto its x axis is zero everywhere except at the origin $(u, v) = (0, 0)$.

C. 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.

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. Rotating an image results in rotating its Fourier Transform.

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

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

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

E. They may be mistakenly interpreted as lower frequencies.

46. 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 each effect the quality of an image and the accuracy of a diagnosis made from that image.

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

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

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

47. 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 distribution function can describe the distribution of values.

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

D. They can only assume integer values.

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

48. 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. positive predictive value

C. prevalence

D. specificity

E. sensitivity

49. 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. $T_x = 1$, $T_y = 1$

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

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

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

50. 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. $f(x, y)$

B. 3

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

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

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

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

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

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

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

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

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

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

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

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

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

53. $f(x)$ 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. 500 Hz

B. 250 Hz

C. 200 Hz

D. 100 Hz

E. 350 Hz

54. If $\mathcal{F}[PSF] = \sqrt{5\pi}e^{-5\pi^2 u^2}$ 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. $e^{5\pi^2 u^2}$

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

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

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

E. $\sqrt{5\pi}$

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

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

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

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

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

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

56. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Diagnostic Accuracy.

A. 0.95

B. .12

C. .10

D. 0.67

E. 1.0

57. 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. Neither of them

B. Cannot be determined

C. I

D. I and II

E. II

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

A. It is a separable function.

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

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

D. It has a magnitude of 1.

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

59. 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 III.

C. II and III.

D. None of them is true.

E. I and II.

60. The axial plane

A. is parallel to the side of the body.

B. is parallel to the coronal plane.

C. is parallel to the front of the body.

D. is used only in projection radiography.

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

61. 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 used to quantify the resolution of that system.

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

D. It characterizes the contrast in the system.

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

62. 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 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 the current temperature at the North Pole is a continuous random variable.

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

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

63. The Greek letter ψ is written in English as

A. psi

B. eta

C. zeta

D. chi

E. phi

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

A. 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.

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

C. 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.

D. 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.

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

65. 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. I, II, and III.

D. II and III.

E. I.

66. 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. ∞

B. $-\infty$

C. -2

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

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

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

A. It exhibits the property of distributivity.

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

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

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

E. It exhibits the property of commutativity.

68. 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 III.

C. I and II.

D. I, II, and III.

E. II and III.

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

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

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

C. It requires circular symmetry.

D. It does not have an inverse transform.

E. It employs a Bessel function.

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

A. MRI

B. PET

C. Ultrasound

D. X-ray

E. CT

71. 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. Specificity

B. Diagnostic accuracy

C. Prevalence

D. Negative predictive value

E. Sensitivity

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

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

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 area under the MTF is always 1.

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

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

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

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

B. They are central to Euler's identity.

C. They can represent any complex number.

D. 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.

E. θ represents temporal or spatial frequency.

74. The Greek letter ϕ is written in English as

A. zeta

B. chi

C. phi

D. psi

E. theta

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

A. Ultrasound and MRI

B. Only CT

C. Only MRI

D. Only ultrasound

E. MRI and CT

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

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

B. It is also known as the Dirac function.

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

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

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

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

A. It is perpendicular to coronal planes.

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

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

D. It represents a tomographic slice.

E. It is perpendicular to axial planes.

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

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

D. 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.

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

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

A. It fully defines a linear system.

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

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. 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.

80. 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. Its mean and standard deviation are equal.

C. It involves a complex exponential.

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

E. It may represent continuous or discrete random variables.

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

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

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

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

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

82. 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 linear

B. System II is linear.

C. System I is linear.

D. Both systems are shift-invariant

E. System I is not shift invariant.

83. 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
B. I and III
C. I, II, and III
D. II and III
E. I and II

84. 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
B. $(x + 1)^2 - 3(y - 3)$
C. $2f(x, y)\delta(x^2, -3y)$
D. $-\infty$ for all x and y.
E. $-16\delta(x + 1, y - 3)$

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

86. 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. 50%,
C. 28%,
D. 70%.
E. 32%.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A. 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.

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

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

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

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

91. 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 express as a function of frequency.

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

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

A. The equations.

B. The pictures from inside the human body.

C. The amazingly machines and physics.

D. The Prince and Links book.

E. The metaphorical approach to the underlying mathematics.

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

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

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

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

D. None is true.

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

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

A. 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.

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

C. All are true.

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

95. 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. 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.

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

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

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

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

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

E. 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.

97. 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. I, II, and III.

C. I.

D. I and III.

E. III

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

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

B. It always has an area of 1.

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

D. It can never be negative.

E. All are true.

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

A. All are true.

B. Its mean and variance are equal.

C. 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.

D. 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.

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

100. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Specificity.

A. .10

B. 1.0

C. .12

D. 0.95

E. 0.67

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

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

102. 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. $rect(x, y) = rect(x)rect(y)$.
C. It is seperable.
D. It has circular symmetry.
E. It is non-periodic.

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

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

104. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Sensitivity.

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

105. 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 at zero frequency is always 0.

C. The area under the MTF is always 1.

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

106. The Greek letter Υ is written in English as

A. zeta

B. upsilon

C. chi

D. phi

E. psi

107. 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 an even function only when $\mu = 0$.

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

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

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

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

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

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. An example of a PMF is the Poisson distribution.

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

C. $f(x, y)$

D. 3

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

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

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

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

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

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

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

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

C. Temporal resolution is limited by the number a images acquired per unit time.

D. 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.

E. 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.

113. 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 system with the poorest resolution (largest R) dominates.

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

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

D. All are true.

E. 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.

114. 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 their sum, N_S, or all are true?

A. All are true.

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

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

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

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

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

A. MRI

B. PET

C. CT

D. Fluoroscopy

E. Ultrasound

116. 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. 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 named in honor of the inventor of the telephone.

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.

117. 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. Specificity

B. Sensitivity

C. Positive predictive value

D. Diagnostic accuracy

E. Prevalence

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

A. θ represents temporal or spatial phase.

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

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

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

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.

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

A. It fully defines a linear system.

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

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

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

E. If the PSF is a delta function, then the system does not change the signal passing through it.

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

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

B. All are true.

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

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.

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BioE 1330 - Review Intro and Chapters 1, 2, and 3 1/17/2011
Answer Sheet - Correct answer is A for all questions

1. Which of the following imaging modalities does 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, $e^{j2\pi(u_0 x+v_0 y)}$, *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 sinusoidal variations at particular orientations, frequency, amplitude, and phase, as determined by the Fourier transform $F(u, v)$.

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

A. The effective PSF for the entire process may be narrower than one or more of the contributing PSFs.

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.

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: The effective PSF cannot be narrower than any of the contributing PSFs. Convolution always smears things out.
[*imaging0012.mcq*]

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

I - It represents the derivative of the probability *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*]

14. 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*]

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

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*]

16. 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*]

17. 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*]

18. 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*]

19. 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*]

20. Please 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 and depict two signals that differ in space, time, or energy as distict.
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*]

21. 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*]

22. 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 heavy from light atoms while MRI differentiates the local environments of hydrogen atoms.

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: CT studies heavy atoms in bone while MRI studies hydrogen atoms in tissue.
[*imaging0022.mcq*]

23. 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*]

24. 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*]

25. 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*]

26. 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*]

27. 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*]

28. 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*]

29. 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*]

30. 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*]

31. 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*]

32. As of 2008, 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*]

33. 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*]

34. 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*]

35. 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*]

36. 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*]

37. 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*]

38. 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*]

39. 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*]

40. 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*]

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

A. They cannot represent a purely real number, because real numbers cannot be raised to an imaginary power.

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: Real numbers can indeed be raised to an imaginary power.
[*imaging0064.mcq*]

42. 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*]

43. 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*]

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

A. The Fourier transform of the projection of an image onto its x axis is zero everywhere except at the origin $(u, v) = (0, 0)$.

B. The "Transfer Function" of a linear shift invariant system is the Fourier transform of its impulse response (or Point Spread Function).

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 the projection of an image onto its x axis is the entire u axis of the Fourier transform of the original image, not just the origin.
[*imaging0067.mcq*]

45. 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*]

46. 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*]

47. 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*]

48. 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*]

49. 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*]

50. 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*]

51. 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*]

52. 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. $\delta(u - 4, v - 1)$
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*]

53. $f(x)$ 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*]

54. 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*]

55. 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*]

56. 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*]

57. 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*]

58. 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*]

59. 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*]

60. 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*]

61. 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*]

62. 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*]

63. 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*]

64. 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 (and usually is) complex, with the real component representing cosines and the imaginary component representing sines.
[*imaging0087.mcq*]

65. 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*]

66. 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*]

67. 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*]

68. 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*]

69. 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*]

70. 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*]

71. 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*]

72. 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*]

73. 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*]

74. 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*]

75. 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*]

76. 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*]

77. 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*]

78. 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*]

79. 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 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*]

80. 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*]

81. 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*]

82. 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*]

83. 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*]

84. 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*]

85. 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*]

86. 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*]

87. 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*]

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

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

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*]

89. 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*]

90. 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*]

91. 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 express as a function of frequency.

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*]

92. 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 amazingly machines and physics.

Explanation: Any answer is considered correct.

Alternate acceptable answer: BCDE
[*imaging0241.mcq*]

93. 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*]

94. 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*]

95. 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*]

96. 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*]

97. 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*]

98. 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*]

99. 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*]

100. 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*]

101. 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*]

102. 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*]

103. 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*]

104. 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*]

105. 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*]

106. 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*]

107. 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*]

108. 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*]

109. 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*]

110. 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*]

111. 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*]

112. 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 a 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*]

113. 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*]

114. 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 their sum, 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*]

115. 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*]

116. 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*]

117. 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*]

118. 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 represents temporal or spatial phase.

D. When multiplied together, they scale each other's magnitudes and rotate 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: Answer A is not true, since if $r = 0$, $re^{j\theta} = 0$
[*imaging0322.mcq*]

119. 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 system.

E. If the PSF is a delta function, then the system does not change the signal passing through it.

Explanation: The PSF is the impulse response itself, not its Fourier Transform.

Alternate acceptable answer: D

Errata: Answer D should read, "It fully defines a linear *shift invariant* system." Just being linear is not enough for it to be completely defined by the PSF.
[*imaging0323.mcq*]

120. 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*]