BioE 1330 - Review Chapter 2 1/26/2010

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.

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

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

B. It has an area of 1.

C. It cannot be integrated.

D. It is infinitely narrow.

E. It is also known as the Dirac function.

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

A. It exhibits the property of associativity.

B. It exhibits the property of commutativity.

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

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

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

3. 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 represents a cosine in the real domain and a sine in the imaginary domain.

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

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

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

4. 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 and II.

D. I.

E. I, II, and III.

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

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

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

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

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

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

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

A. 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.

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

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

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. 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.

7. 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. Neither of them

B. I

C. II

D. I and II

E. Cannot be determined

8. Determine which of the following signals are separable.

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

A. I

B. I and II

C. I and III

D. I, II, and III

E. II

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

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

A. II

B. I and II

C. I, II, and III

D. I

E. II and III

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

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

D. 3

E. 5

11. 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. Cannot be determined

D. I and II

E. I

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

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

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

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

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

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

13. 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. Parseval's Theorem: $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |f(x, y)| dx dy = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |F(u, v)| du dv$
D. Translation/Shifting: $F_{2D}(f(x - x_0, y - y_0))(u, v) = F(u, v)e^{-j2\pi(ux_0 + vy_0)}$
E. Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$

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

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

A. They represent projections through the human body.
B. Examples of tomographic image modalities includes MRI and CT.
C. Each pixel represents a localized sample in space.
D. They are called 'tomographic' because *tomos* is Greek for 'slice'.
E. They can be coronal, sagittal, or axial.

16. The Greek letter ξ is written in English as

A. zeta
B. xi
C. chi
D. phi
E. eta

17. 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. II only
C. I and III
D. None.
E. I and II

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

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

A. II only

B. I, II, and III

C. I and III

D. None.

E. I and II

19. 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 are central to Euler's identity.

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

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

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

20. The Greek letter η is written in English as

A. zeta

B. xi

C. phi

D. chi

E. eta

21. 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 and III.

C. I, II, and III.

D. I.

E. II and III.

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

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

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

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

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

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

D. They may be mistakenly interpreted as lower frequencies.

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

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

A. $T_x = 6$, $T_y = 2$
B. $T_x = \frac{1}{3}$, $T_y = 1$
C. $T_x = \frac{1}{2}$, $T_y = \frac{1}{2}$
D. $T_x = 3$, $T_y = 1$
E. $T_x = 1$, $T_y = 1$

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

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

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

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

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

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

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

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

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

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

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

A. Cannot be determined

B. Neither of them

C. I and II

D. II

E. I

29. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0 x + v_0 y)}$, *except*

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

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

C. It has a magnitude of 1.

D. It is a separable function.

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

30. The Greek letter ψ is written in English as

A. chi

B. psi

C. eta

D. zeta

E. phi

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

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

B. 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.

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

D. 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.

E. 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.

32. 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 II.

B. II and III.

C. I and III.

D. I.

E. I, II, and III.

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

E. $-\infty$

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

A. It exhibits the property of distributivity.

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

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

D. It exhibits the property of commutativity.

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

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

A. It requires circular symmetry.

B. It employs a Bessel function.

C. It does not have an inverse transform.

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

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

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Answer Sheet - Correct answer is A for all questions

1. 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*]

2. 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*]

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

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

B. Complex conjugate pairs of these complex exponentials form 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*]

4. 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*]

5. 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*]

6. 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*]

7. 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*]

8. 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*]

9. 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 they are not guaranteed to have the same frequencies or even a whole number ration between their frequencies, the function is not periodic.
[*imaging0017.mcq*]

10. 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*]

11. 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*]

12. 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*]

13. 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*]

14. The line spread function for a medical imaging system is given as
$l(x) = 4\cos(\alpha x)$ for $|x| \le \frac{\pi}{20}$ 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*]

15. 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*]

16. 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*]

17. 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*]

18. 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*]

19. 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*]

20. 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*]

21. 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*]

22. 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*]

23. 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*]

24. 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*]

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

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*]

26. 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*]

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

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

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

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

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

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

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

28. 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*]

29. The following is true of the 2D complex exponential function, $e^{j2\pi(u_0 x + v_0 y)}$, *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*]

30. 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*]

31. 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*]

32. 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*]

33. 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*]

34. 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*]

35. 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*]