BioE 1330 - Exam 1 2/9/2010
Answer Sheet - Correct answer is A for all questions

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

A. Convolution with a Gaussian of non-zero width in the spatial domain boosts the high frequencies.

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

C. It exhibits the property of commutativity.

D. Convolution with an impulse function yields the impulse response.

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

Explanation: Convolution with a Gaussian of non-zero width in the spatial domain boosts the *low* frequencies.
[*imaging0026.mcq*]

2. 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*]

3. 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*]

4. 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*]

5. 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*]

6. 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*]

7. 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*]

8. 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*]

9. 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 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*]

10. 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*]

11. 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*]

12. 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*]

13. 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*]

14. Determine which of the following are periodic.

I - $e^{j2\pi(ux+vy)} + e^{-j2\pi(ux+vy)}$
II - $\sum_{x=0}^{\infty} \delta(x)$
III - $f(m, n) = \sin(\frac{1}{5m}) \cos(\frac{1}{5m})$, for all $m \neq 0$

A. I and III

B. I

C. I and II

D. II and III

E. I, II, and III

Explanation: II is not periodic because the sum only starts at 0, not $-\infty$.

Alternate acceptable answer: B

Errata: It should read, "Determine which of the following signals are periodic in both x and y," and function III is poorly written (see question 9 in the review questions for Chapter 2, imaging0017.mcq).
[*imaging0232.mcq*]

15. 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*]

16. 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*]

17. 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*]

18. 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 *specificity* of the physical examination

A. 68%

B. 32%.

C. 70%.

D. 50%,

E. 28%,

Explanation: $((2500 - 800)/2500) * 100$

Alternate acceptable answer: BCDE

Errata: It should be 2,500 controls, not 5,000 controls. That gives the equation in the explanation above.
[*imaging0235.mcq*]

19. 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*]

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

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

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

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

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

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

Explanation: All of the properties are correctly written except Scaling, which is incorrect in the Fourier Transform multiplying, rather than dividing, by the scaling term: Scaling: $F_{2D}(f(ax, by))(u, v) = \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$. Stretching in space means compressing in frequency (lower frequencies).
[*imaging0237.mcq*]

21. 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*]

22. 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*]

23. 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*]

24. 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*]

25. 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*]