

Final Exam

12/9/11

Maximum points: 70

1. Which of the following tests depends on a psychophysical rather anatomic or neurophysiological approach to evaluate the visual system?

- a. Amsler's Grid
- b. Interferometry
- c. Photostress (brightness recovery)
- d. Matrix frequency doubling perimetry
- e. **They all use a psychophysical approach.**

2. In an experiment to determine the minimum amount of light detectable by the human eye, you must optimize test conditions. All of the following would help, except one. Which one?

- a. **Have the subject direct fixate the place where the stimulus will appear.**
- b. Set the stimulus wavelength to match the peak of scotopic sensitivity function.
- c. Flash the stimulus for less than the temporal summation critical duration (100 msec).
- d. Design the stimulus so it is smaller than the spatial summation zone (10 arc min).
- e. Dark adapt the subject for at least 45 minutes.

3. Which of the following may be considered an ocular aberration?

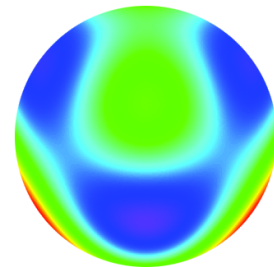
- a. Myopia
- b. Astigmatism
- c. Coma
- d. **All of the above**
- e. None of the above

4. Which of the following designates spherical aberration in the Zernike system?

- a. Z_2^0
- b. Z_3^{-3}
- c. Z_3^1
- d. **Z_4^0**
- e. Z_4^2

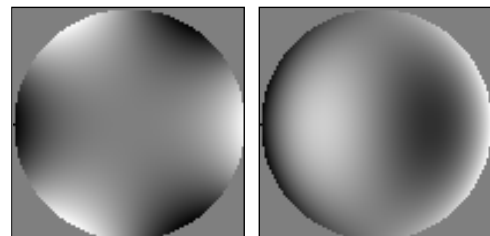
5. The figure to the right shows a higher-order wavefront aberration map. Which of the following aberrations appears to be most prominent in this eye?

- a. spherical aberration
- b. astigmatism
- c. **trefoil**
- d. coma
- e. spherical defocus



6. Which Zernike order contains the aberrations shown by the two wavefront maps to the right.

- a. First
- b. Second
- c. **Third**
- d. Fourth
- e. None of the above

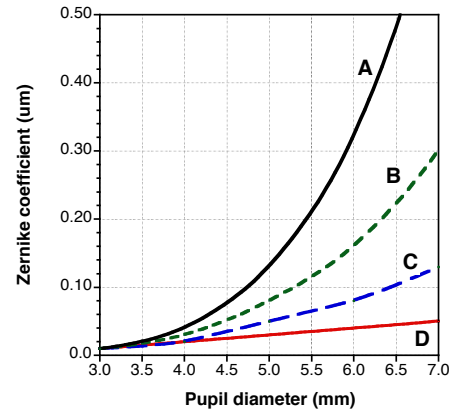


7. If an eye's higher-order aberrations consist of all the third-order modes plus fourth order spherical aberration only, each with a magnitude of $0.1 \mu\text{m}$, what would the total higher order RMS wavefront error be? Choose the closest answer.

- a. $0.1 \mu\text{m}$
- b. $0.2 \mu\text{m}$
- c. $0.3 \mu\text{m}$
- d. $0.4 \mu\text{m}$
- e. $0.5 \mu\text{m}$

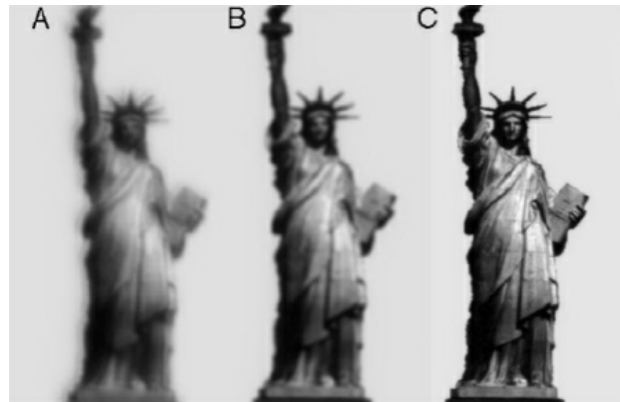
8. Which of the curves, shown in the figure to the right, best plots the change in the RMS value for Z_4^0 when the pupil dilates from 3.0 to 7.0 mm? The Z_4^0 for a 3.0-mm pupil is $+0.01 \mu\text{m}$.

- a. Curve A
- b. Curve B
- c. Curve C
- d. Curve D
- e. None of the above is close.



9. The figure to the right shows the simulated retinal image of the Statue of Liberty, seen at distance, for a normal emmetropic eye, under three conditions. The pupil diameter was either 3 or 8 mm, and the higher-order aberrations (HOA) were either uncorrected or corrected. Which of the following would have the best image quality, as show in Figure C?

- a. 3-mm pupil, HOA uncorrected.
- b. 3-mm pupil, HOA corrected
- c. 8-mm pupil, HOA uncorrected
- d. 8-mm pupil, HOA corrected
- e. All of the above



10. Which of the following is closest to the mean higher-order RMS wavefront error expected for a normal adult eye with a 6.0-mm pupil?

- a. $0.1 \mu\text{m}$
- b. $0.2 \mu\text{m}$
- c. $0.3 \mu\text{m}$
- d. $0.5 \mu\text{m}$
- e. $0.7 \mu\text{m}$

11. Among the following choices, which includes terms that are all consistent with good visual performance on a Humphrey visual fields test?

- a. High decibel value, dim light, low threshold
- b. Low decibel value, dim light, high threshold
- c. High decibel value, bright light, high threshold
- d. Low decibel value, dim light, low sensitivity
- e. High decibel value, dim light, low sensitivity

12. Which of the following best summarizes the extent of the normal visual field, in degrees, in the four cardinal directions?

	superior	nasal	inferior	temporal
a.	60	50	90	90
b.	50	60	70	90
c.	30	40	50	60
d.	70	80	90	100
e.	60	50	70	90

13. The Humphrey Visual Field Analyzer projects a white spot with a maximum luminance of 10,000 apostilbs onto the background. It uses neutral density filters to adjust brightness of the spot below 10,000 apostilbs. What luminance value, in nits, corresponds with a setting of 23 decibels?

- a. 15
- b. 50
- c. 150
- d. 200
- e. 315

14. In heterochromatic flicker photometry, done under photopic conditions with a reference wavelength of 555 nm, the flicker will be minimized when the reference and test wavelengths have the same ...

- a. radiance.
- b. frequency.
- c. power.
- d. hue.
- e. luminance.

15. Which of the following is a photometric unit for illuminance?

- a. Nits (candelas/m²)
- b. Lux
- c. Watts
- d. Apostilbs
- e. Steradian

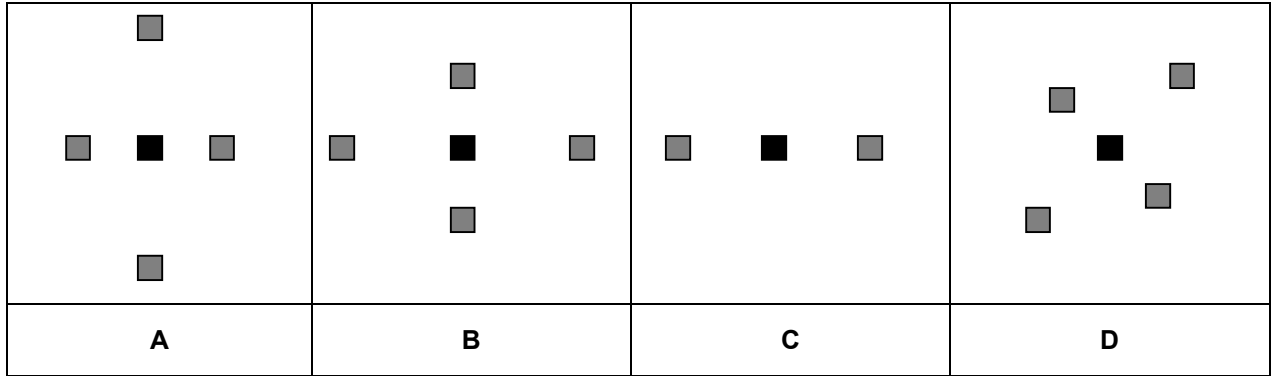
16. Which of the following is a photometric unit for luminance?

- a. Nits (candelas/m²)
- b. Lux
- c. Watts
- d. Steradian
- e. Candellas

17. Which of the following correctly describes the relationship between illuminance and luminance?

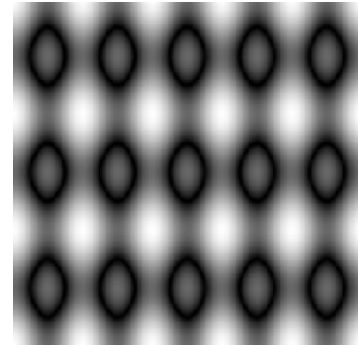
- a. Illuminance and luminance are different names for the same quantity.
- b. For a 100% Lambertian reflector, the luminance in lux equals the illumination in candelas/m².
- c. For a 100% Lambertian reflector, the luminance in apostilbs equals the illumination in candelas/m².
- d. For a 100% Lambertian reflector, the luminance in nits equals the illumination in apostilbs.
- e. For a 100% Lambertian reflector, the luminance in apostilbs equals the illumination in lux.

18. Suppose you want to include a photograph on your web page, but it is slightly blurry. Which of the following techniques would give the photograph a sharper appearance?
- Decrease the contrast.
 - Apply a low-pass filter.
 - Apply a band-pass filter.
 - Make the image larger.
 - Make the image smaller.**
19. Fifteen minutes after completely bleaching the rhodopsin in the retina, how much of the rhodopsin will have recovered?
- 10%
 - 50%
 - 75%
 - 87%**
 - 100%
20. Size constancy causes ...
- retinal image size to decrease with the square of the object distance.
 - a constant retinal image size for an object viewed at different viewing distances.
 - the same object viewed at different distance to appear the same size.**
 - retinal image size to decrease as objects get farther away.
 - the waterfall illusion.
21. Why should you use a red light to read in the dark if you want to preserve dark adaptation?
- Red light stimulates both rods and cones, and rods absorb red light relatively poorly.**
 - Red light stimulates the cones, but not the rods.
 - Red light stimulates the rods, but not the cones.
 - Red light is not absorbed by either the rods or cones.
 - Red light stimulates both rods and cones, but rods are most sensitive to red light.
22. An abnormally long recovery time in the photostress test usually indicates a problem with the ...
- optic nerve.
 - macula.**
 - intraocular pressure.
 - higher-order aberrations.
 - light adaptation.
23. As vision adapts to a brighter background, what happens to sensitivity for detecting a fixed increment of light that is added to the background? Sensitivity ...
- remains constant.
 - increases.
 - decreases.**
 - fluctuates between increasing and decreasing sensitivity.
 - None of the above
24. Cells and flare are a sign of iritis, but can be very difficult to see during a slit lamp exam. Which of the following does not explain how to improve visibility of the cells and flare?
- Increase intensity of the slit lamp beam to increase the luminance increment of the cells relative to the background.
 - View the cells against a background with minimal luminance, such as the black pupil.
 - Allow your eyes to dark adapt to increase sensitivity.
 - Increase the luminance increment of the cells relative to the background so it exceeds Weber's fraction.
 - Increase Weber's fraction so it exceeds the ratio of the luminance increment relative to the background.**



25. The figures above (A, B, C, D) represent magnified views of the center of an image's spatial frequency spectrum. The squares represent non-zero values. Which figure most closely corresponds with the pattern shown to the right?

- a. Spectrum A
- b. **Spectrum B**
- c. Spectrum C
- d. Spectrum D
- e. All of the above



26. According to Ricco's Law, for spot diameters smaller than the critical diameter, the intensity (quanta/area) of the spot necessary for detection

- a. **must increase for smaller spot diameters.**
- b. must decrease for smaller spot diameters.
- c. must remain constant for all spot diameters.
- d. is unrelated to spot diameter.
- e. None of the above

27. According to Bloch's Law, for durations within the critical duration, the product of intensity (quanta/time) and time

- a. must increase with increasing duration.
- b. must decrease with increasing duration.
- c. **must remain constant.**
- d. is unrelated to duration.
- e. None of the above

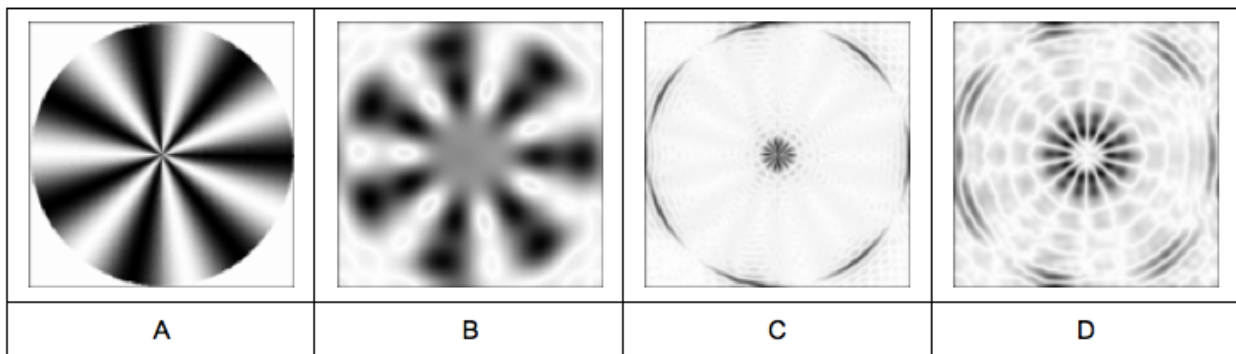


Image A was spatially filtered to produce Images B, C and D. For the following questions, choose the Image (A, B, C, or D) that best matches the description.

28. After processing Image A, it looks like B. In terms of what you learned about Fourier transformation and spatial filtering what process was used to make Image B? It has been ...

- a. high-pass filtered.
- b. low-pass filtered.
- c. band-pass filtered.
- d. high- and low-pass filtered.
- e. transformed into its spatial frequency spectrum.

29. After processing Image A, it looks like C. What happened? It has been ...

- a. high-pass filtered.
- b. low-pass filtered.
- c. band-pass filtered.
- d. high- and low-pass filtered.
- e. transformed into its spatial frequency spectrum.

30. After processing Image A, it looks like D. What happened? It has been ...

- a. high-pass filtered.
- b. low-pass filtered.
- c. band-pass filtered.
- d. high- and low-pass filtered.
- e. transformed into its spatial frequency spectrum.

31. According to the Ferry-Porter law, the CFF ...

- a. increases as the log of stimulus area.
- b. is directly proportional to stimulus luminance.
- c. is inversely proportional to the log of the stimulus luminance.
- d. is directly proportional to the log of the stimulus luminance.
- e. None of the above.

32. Which of the following correctly describes the relationship between the size of a flashing light (of fixed radiant power) and how well a person can see high frequency flicker?

- a. If a flashing light gets smaller, the flicker will become more visible.
- b. The fastest flicker that a person can see remains constant for flashing lights of any size.
- c. If a light becomes dimmer and smaller, the flicker will become more visible.
- d. If a flashing light gets larger, the flicker will become more visible.

33. According to the Broca-Sulzer effect, ...

- a. the longer a light (with fixed radiant power) is left on, the brighter it appears to become.
- b. light that enters the peripheral pupil appears dimmer than light entering the center.
- c. a light that is flashed on for 50-100 msec will look slightly dimmer than a steady light of the same radiant power.
- d. a light that is flashed on for 50-100 msec will look slightly brighter than a steady light of the same radiant power.
- e. wavelengths above 500 nm appear to become more yellow with increasing intensity.

34. According to the Talbot-Plateau law, how will the brightness of a light that is flickering above the CFF compare to a steady non-flickering light that has the same radiance?

- a. The flickering light will have the same brightness.
- b. The flickering light will appear brighter.
- c. The flickering light will appear dimmer.
- d. All of the above
- e. None of the above

Reference formulas

$$J_{45} = -\frac{C}{2} \sin(2A)$$

$$M = S + \frac{C}{2}$$

$$J_{180} = -\frac{C}{2} \cos(2A)$$

$$C = -2\sqrt{J_{45}^2 + J_{180}^2}$$

$$S = M - \frac{C}{2}$$

$$A = \frac{1}{2} \tan^{-1}\left(\frac{J_{45}}{J_{180}}\right)$$

$$J_{45} = (-2\sqrt{6}) \frac{C_2^{-2}}{y^2}$$

$$M = (-4\sqrt{3}) \frac{C_2^0}{y^2}$$

$$J_{180} = (-2\sqrt{6}) \frac{C_2^2}{y^2}$$

For Questions 35-37

A toric soft contact lens with a power of -2.50 -1.50 x 180 rotates 10° clockwise on the eye. The over-refraction is, -0.75 - 1.00 x 045. What contact lens power should you order for this eye? (For sphere and cylinder choose the nearest 0.25 diopter; axis the nearest 10°)

35. The sphere power is ...

- a. -3.25
- b. -3.50
- c. -3.75
- d. -4.00
- e. -4.25

36. The cyl power is ...

- a. -1.00
- b. -1.25
- c. -1.50
- d. -1.75
- e. -2.00

37. The axis is ...

- a. 180
- b. 10
- c. 20
- d. 30
- e. 40

For Questions 38-40

An aberrometer reports the following values (in μm) for an eye's second-order aberrations: $C_2^{-2} = -0.50$, $C_2^0 = 4.0$, $C_2^2 = -0.50$ (6.0-mm diameter pupil). Convert this to the equivalent sphere, cylinder and axis. (For sphere and cylinder choose the nearest 0.25 diopter; axis the nearest 10°)

38. The sphere power is ...

- a. -1.50
- b. -1.75
- c. -2.00
- d. -2.25
- e. -2.50

39. The cyl power is ...

- a. -0.25
- b. -0.50
- c. -0.75
- d. -1.00
- e. -1.25

40. The axis is ...

- a. 10
- b. 20
- c. 30
- d. 40
- e. 50

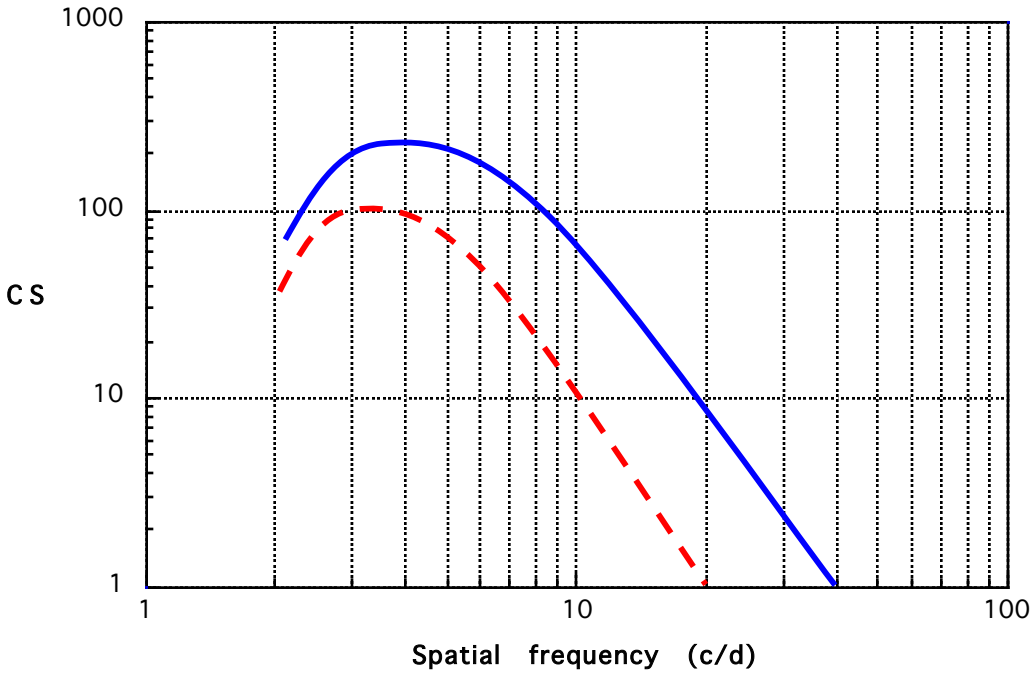
41. If a patient can read as far down as 2 out of 5 letters on the 0.1 line of the ETDRS chart, what is the closest equivalent Snellen visual acuity?

- a. 20/16
- b. 20/20
- c. 20/25
- d. 20/30
- e. 20/35

42. Suppose a patient had supernormal vision due to a perfect optical correction. If he could read 20/8, what would the equivalent logMAR visual acuity be?

- a. 2.5
- b. 0.4
- c. -0.2
- d. -0.3
- e. -0.4

43. On a standard logMAR visual acuity chart letter, the linear size of a letter doubles every _____ line(s). (How many lines?)
- one
 - two
 - three
 - four
 - five



44. What is the high-contrast visual acuity (Snellen equivalent) for the eye represented by the lower curve?
- 20/10
 - 20/15
 - 20/20
 - 20/30
 - 20/60
45. Referring to the upper curve, what would this eye's maximum visual acuity be for 1% contrast?
- 20/60
 - 20/70
 - 20/85
 - 20/100
 - 20/120
46. What is the lowest contrast that the better eye can see?
- 0.1%
 - 0.5%
 - 1%
 - 2%
 - 10%

47. Assume that a patient has a normal contrast sensitivity function and is barely able to see a low-contrast sine wave grating that has a spatial frequency of 4 cycles per degree. Which of the following best describes how this eye would see?

- a. Visibility of the gratings will not change as a function of distance.
- b. If he views the chart from half the distance, the gratings will become easier to see.
- c. If he views the chart from twice the distance, the gratings will become easier to see.
- d. If he views the chart from half the distance, the gratings will become harder to see.
- e. None of the above.

48. With perfect optics visual resolution at the fovea is limited by the density of the foveal cones. In the periphery the ganglion cell spacing rather than cone density determines the Nyquist limit. If we measure a visual acuity equal to 20/200 in the peripheral retina, how far apart must the ganglion cells be spaced? Assume that one degree on the retina is 300 μm wide.

- a. 45 μm
- b. 50 μm
- c. 55 μm
- d. 60 μm
- e. > 70 μm

49. Under ideal conditions, vernier acuity thresholds can be as good as ...

- a. 2 to 10 arc seconds.
- b. 2 to 10 arc minutes.
- c. 2 to 10 degrees.
- d. 2 to 10 radians.
- e. 2 to 10 steradians.

50. Assuming a critical duration of 10 milliseconds, which of the following is not correct?

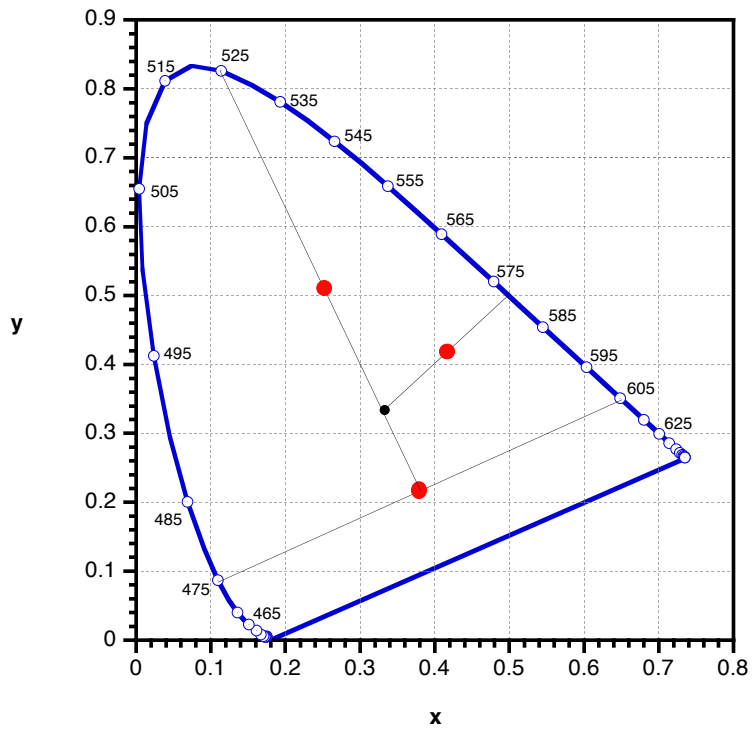
- a. If a light (with 75% of threshold luminance) is flashed, then 90 milliseconds later re-flashed, the person will see no flash.
- b. If a light (with 75% of threshold luminance) is flashed, then 5 milliseconds later re-flashed, the person will see one flash.
- c. If a light (with 125% of threshold luminance) is flashed, then 25 milliseconds later re-flashed, the person will see two flashes.
- d. If a light (with 75% of threshold luminance) is flashed, then 2 milliseconds later re-flashed, the person will see two flashes.
- e. All of the above

51. Assume that a patient has a pupil diameter of 4.0 mm for OD and 6.0 mm for OS and normal color perception. What should he notice when looking at a green (550 nm) light? Compared to the appearance seen by OD, the light seen by OS should appear ...

- a. brighter but with the same hue.
- b. brighter but appear to be blue-green.
- c. the same brightness and same hue.
- d. dimmer but have the same hue.
- e. brighter but appear to be yellow-green

52. Which of the following would most likely indicate an acquired color anomaly?

- a. Male patient with long-standing deuteranomaly
- b. Female patient with long-standing deuteranomaly.
- c. Male patient with recently diagnosed protanomaly.
- d. Female patient with recently diagnosed protanomaly.
- e. All of the above indicate a hereditary anomaly



53. Compute the result of mixing 475, 525 and 605-nm monochromatic lights in a ratio of 1:2:1. Mark your answer on the CIE diagram above and choose the closest (x, y) chromaticity coordinates below.

- a. (0.40, 0.20)
- b. (0.50, 0.25)
- c. (0.33, 0.33)
- d. (0.70, 0.15)
- e. (0.25, 0.50)

54. What would the excitation purity be (to the nearest 0.1) for a color that lies halfway between point (0.33, 0.33) and (0.5, 0.5)?

- a. 0.1
- b. 0.3
- c. 0.7
- d. 1.0
- e. None of the above

55. What would its dominant wavelength be? Choose the closest answer.

- a. 480
- b. 515
- c. 575
- d. 605
- e. 700

56. Compared to what a normal trichromat would see, how should the red signal of a traffic light appear to a protanomalous trichromat? It would look ...
- normal.
 - brighter than normal but desaturated.
 - brighter and more saturated.
 - dimmer and more saturated.
 - dimmer and less saturated.**

H R R PSEUDOISCHROMATIC PLATES

NAME..... DATE..... EXAMINER.....

1-4 DEMONSTRATION SERIES
Four plates. Do NOT score.

SCREENING SERIES

Defect	Test	Repetition	Protan	Deutan	SCREENING SERIES ANALYSIS
B-Y Defect	5 O,X	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Normal.....
	6 O,∇	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Defective: B-Y.....
	7 X,▶	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	R-G.....
	8 O,▶	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
R-G Defect	9 O	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	10 X	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	11	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	12	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Mild R-G Defect	13	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	14	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	15	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	16	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Medium R-G Defect	17	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	18	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	19	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	20	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Strong R-G Defect	21	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	22	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	23	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
	24	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	

DIAGNOSTIC SERIES ANALYSIS

Type:

Protan.....

Deutan.....

Tritan.....

Tetartan.....

Unclassified.....

EXTENT:

Mild.....

Medium.....

Strong.....

Total Tritan Tetartan

Total Laminated Version P/N 4458

1021 South Rogers Circle, Suite 6 Boca Raton, FL 33487

57. Based on the HRR test response shown above, what is the diagnosis?

- Strong protan**
- Strong deutan
- Medium protan
- Medium deutan
- Medium trichromat

58. A patient uses an anomaloscope to mix monochromatic green and red lights to obtain a metameric match with monochromatic yellow. No matter what the mixture setting is, the hues appear to match, but the brightness fluctuates depending on how he sets the mixture. He has ...

- protanomaly
- protanopia**
- deuteranomaly
- deuteranopia
- tritanopia

59. Assume that another patient would only accept a certain mixture setting that had a slightly greater than normal amount of green, but had a normal luminance setting. He would have ...

- protanomaly
- protanopia
- deuteranomaly**
- deuteranopia
- tritanopia

60. The standard ERG test would be most useful in diagnosing which of the following?

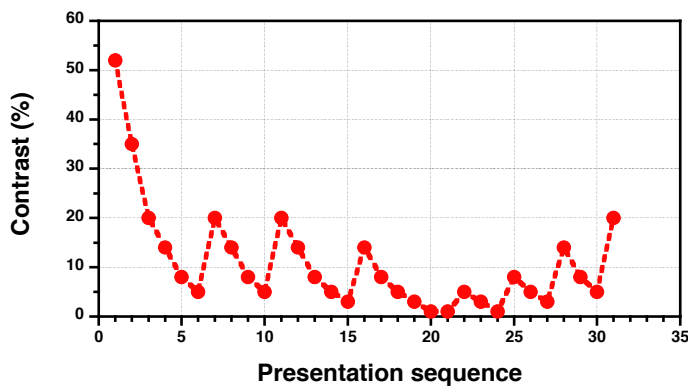
- a. Optic neuritis
- b. Retinitis pigmentosa
- c. Stargardt's disease
- d. Pinguecula
- e. Keratoconus

61. The VER test would be most useful in diagnosing which of the following?

- a. Optic neuritis
- b. Retinitis pigmentosa
- c. Peripheral retinal hole
- d. Pinguecula
- e. Keratoconus

62. How does the Humphrey Matrix frequency doubling technology perimeter work to isolate the magnocellular ganglion cells from the parvocellular neurons?

- a. The parvo non-linear response doubles the frequency seen by the magnocellular system.
- b. The grating flickers so rapidly that it cannot be temporally resolved the parvo system.
- c. The grating flickers so rapidly that it cannot be temporally resolved the magno system.
- d. The counter-phase flickering grating is fused into a uniform gray field by the parvo system.
- e. Both b and d work together.



63. The graph above plots the results of a contrast threshold experiment. What is the best estimate of the threshold?

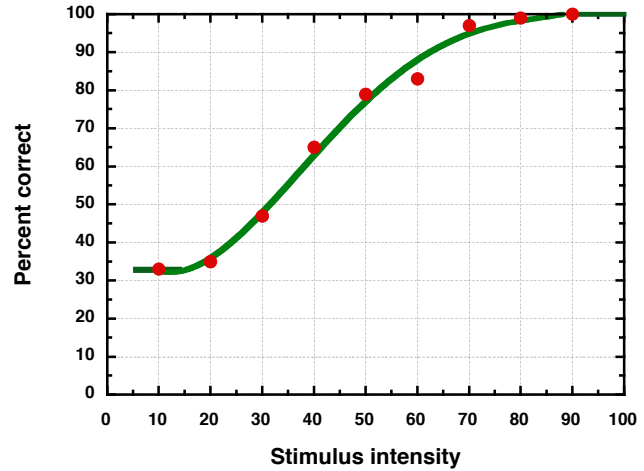
- a. <1%
- b. 2%
- c. 5%
- d. 10%
- e. 20%

64. Some studies indicate that over time, neural adaptation develops to compensate for higher-order aberrations. If you perfectly corrected all lower and higher-order aberrations, how would the visual acuity of a keratoconic and simple myope compare immediately after correction?

- a. The visual acuity of both should improve equally.
- b. The visual acuity of both should show no significant improvement.
- c. Visual acuity for the keratoconic should be better than the myope.
- d. Visual acuity for the myope should be better than the keratoconic.
- e. None of the above.

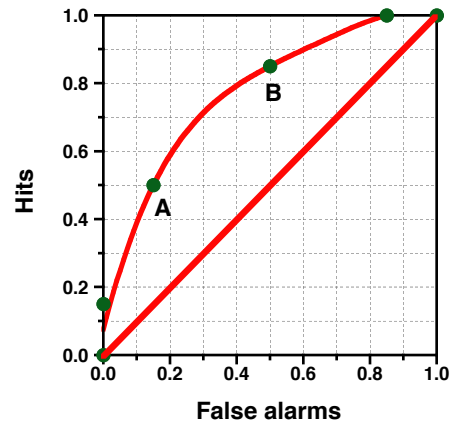
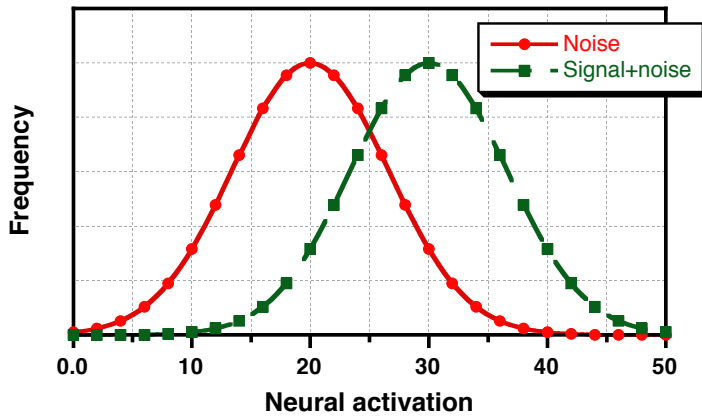
65. The figure to the right shows results from a constant stimuli experiment. Which of the following techniques was probably used?

- a. Yes/no detection
- b. Method of adjustment
- c. Staircase
- d. 2AFC
- e. 3AFC



66. What percentage of correct answers would usually correspond most closely to the threshold? Choose the closest answer.

- a. 35%
- b. 45%
- c. 55%
- d. 65%
- e. 75%



67. Refer to the figure above showing the noise (left curve) and signal plus noise (right curve) distributions. If the criteria for detection were set to 25, what would the false alarm and hit rates be?

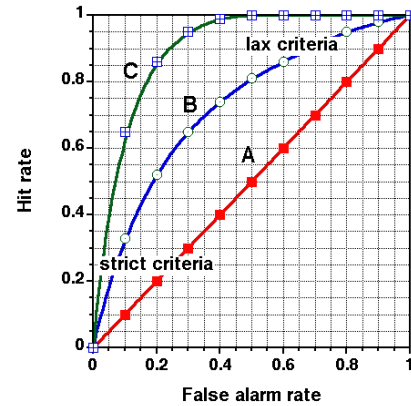
- a. 0.35 and 0.35
- b. 0.65 and 0.65
- c. 0.35 and 0.65
- d. 0.65 and 0.35
- e. 0.50 and 0.50

68. If the detection criterion were set to 25, what would the specificity be?

- a. 0.35
- b. 0.45
- c. 0.50
- d. 0.55
- e. 0.65

69. Which of the ROC curves to the right indicates the best diagnostic test?

- a. Curve A
- b. Curve B
- c. Curve C
- d. All of the above



70. An eye chart displays several rows of gray letters on a white background. All of the letters have the same contrast, but they vary in size from top to bottom. This chart tests ...

- a. Low contrast visual acuity
- b. High contrast visual acuity
- c. Contrast sensitivity
- d. Contrast threshold
- e. None of the above



Dear students,

It has been a privilege and blessing to have worked with you this semester. I hope our study of vision science was somewhat interesting and that it will make you better doctors. Please do your best in the finals and then enjoy a well-deserved Christmas break. Merry Christmas!

-- Dr. Salmon