VS203B Sample Exam Questions

Typical 1-point multiple choice questions

1. Which **one** of the following statements is most **correct**?
Before a bubble gets too thin and bursts….
a) the bubble appears bluish, then the reflections disappear, then the bubble bursts.
b) the bubble appears reddish, then the reflection turns white because all light reflects, then the bubble bursts.
c) the bubble appears bluish, then the reflection appears white because all light reflects, then the bubble bursts.
d) the bubble appears reddish, then the reflections disappear, then the bubble bursts.

2. Which **one** of the following statements is **correct**?
The *sinc* function is defined as…
a) the intensity pattern generated in the far-field by diffraction through a slit aperture.
b) the intensity of a cross section of the Airy disk from a circular aperture.
c) a basin which is used to contain or dispose of liquids.
d) the intensity of the interference patterns generated through a double-slit aperture.

3. Which **one** of the following statements is **correct**?
Light is modeled as a transverse wave rather than a longitudinal wave…
a) because light can travel through a vacuum.
b) to allow us to model the polarization of light.
c) because the energy in light oscillates in a direction that parallel to its propagation direction.
d) so that we can predict the effects of astigmatism.

4. Which **one** of the following statements is **incorrect**?
Fraunhofer diffraction patterns…
a) are observed at the focal plane of a lens.
b) are observed when the screen is held far from the aperture.
c) arise because of the interference of light.
d) are observed when a screen is held near to the aperture.

5. Which **one** of the following statements is **correct**?
When an optical system is said to be diffraction-limited, it means that…
a) there are no wavefront aberrations to blur the image.
b) the image screen is held either far from the optical system or at its focal point.
c) it is focused at the hyperfocal distance.
d) the images are free from any blur.

6. Which **one** of the following statements is **correct**?
Coherence length is defined as…
a) the distance a wave travels in one period, T.
b) the average path difference between two waves from the same source for which they can still interfere with each other.
c) the distance between the minima on either side of the central peak in a Fraunhofer diffraction pattern from a slit aperture.
d) the minimum thickness of a coating required for an effective anti-reflection coating.

7. Which **one** of the following statements is **correct**?
When two waves are mutually coherent, it means that….
a) their combined intensity is the linear sum of their individual intensities.
b) the phase difference between the waves does not change over time.
c) the waves will constructively interfere.
d) the phase difference between the two waves changes at a constant rate.

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8. Which **one** of the following statements is **correct**?

The index of refraction of an ideal antireflection coating has to satisfy the equation $n_c = \sqrt{n_g}$ …

a) to ensure that there is no 180 degree phase change at the coating/spectacle interface.
b) to compensate for the change in wavelength as the light passes through the media with different refractive indices.
c) to minimize the amplitude of the reflection at each surface.
d) to make the amplitude of the reflection at the first surface the same as the second surface.

9. Which **one** of the following statements is **correct**?

Barrel distortion is caused by…

a) a decrease in magnification of an optical system as the object is moved away from the optical axis.
b) an increase in magnification of an optical system as the object is moved away from the optical axis.
c) an increase in the spherical aberration of an optical system as the object is moved away from the optical axis.
d) a decrease in the magnification of an optical system as the radius of the aperture in an optical system increases.

10. As the refractive efficiency (aka nu-value, V-value, Abbe number or constringence) of a lens increases, the magnitude of the chromatic aberration of a lens

a) increases.
b) decreases.

11. When an image of an object has a magnification that increases with the object's distance from the axis, the resulting lens is said to produce

a) spherical aberration.
b) Prentice's effect.
c) pincushion distortion.
d) curvature of field.

12. For an off-axis object being imaged through a lens, the plane that contains the chief ray from the object and the optical axis is called the

a) tangential axis.
b) sagittal axis.

13. Choose the **one** statement that is **incorrect**:

a) Distortion is an aberration that does not blur the image of an object.
b) Spherical aberration only occurs for on-axis objects.
c) In a centered optical system with spherical lenses, spherical aberration and coma increase at a faster rate than astigmatism, so even though astigmatism may dominate for small pupils, spherical aberration and coma will be the main aberrations blurring the image for large pupils.
d) Astigmatism occurs for toric surfaces and also for optical systems with spherical surfaces when the object being imaged is held off axis.

Answers

1) a
2) a
3) b
4) d
5) a
6) b
7) b
8) d
9) a
10) b
11) c
12) a
13) b

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Typical 2-point multiple choice questions

1. What is the Rayleigh resolution limit at 450 nm for an eye with a 5 mm pupil size?
a) 0.377 minutes of arc
b) 0.310 minutes of arc
c) 0.0063 minutes of arc
d) 0.00011 minutes of arc

2. Light has a frequency of 4.74×10^{14} Hz. How many wavelengths of this light are there in a 1 mm thick piece of glass with an index of 1.5?
a) 1.58×10^{3}
b) 2.37×10^{3}
c) 1.58×10^{6}
d) 2.37×10^{6}

3. To resolve the **E** on a Snellen chart, you have to resolve the separation between two adjacent arms of the letter. According to Rayleigh's criterion for resolution, what pupil size would the eye need in order to just resolve a 20/10 letter in 550 nm light? (A 20/10 letter has a 1 minute of arc separation between adjacent arms on the **E**. Assume that the eye has no aberrations)
a) 2.31 mm
b) 4.03 mm
c) 4.61 mm
a) 6.71 mm

4. What diameter does an Earth-based telescope have to be to resolve two point sources on the moon that are separated by 3 meters? Assume that i) the moon orbits at 384,400 km above the earth, ii) the night sky is clear with no turbulence in the atmosphere, iii) the wavelength of the reflected light is narrow and centered at 600 nm and v) the telescope is diffraction-limited
a) 9.379 m
b) 93.79 m
c) 937.9 m
d) 9.379 km

5. Light incident on a 0.15 mm wide slit forms a diffraction pattern on a screen 6 m away. If the first minimum of the diffraction pattern is 2 cm from the central peak, what is the wavelength of the incident light?
a) 350 nm
b) 420 nm
c) 500 nm
d) 550 nm

6. What is Brewster's angle for light reflecting off a water-glass interface (n_{water}=1.33, n_{glass} = 1.5)?
a) 41.56˚
b) 48.43˚
c) 56.31˚
d) 90˚

7. For a lens (in air) the rays entering the lens margin from a distant on-axis object focus at a distance of 1 m. The rays from the same object passing through the center of the lens focus at 50 cm. What is the spherical aberration of the lens in diopters?
a) -1.00 D LSA
b) +1.00 D LSA
c) -0.5 D LSA
d) +0.5 D LSA

answers: 1) a; 2) b; 3) c; 4) b; 5) c; 6) b; 7) a

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Typical Multiple Point Problems

1. **(2 points)** The typical human eye has an optimal pupil size somewhere between 2 and 3 mm. For smaller pupils, the image quality reduces because of an increase in blur due to _____. For larger pupils the image quality is reduced because of an increase in blur due to _____.

2. **(9 points total)** A light wave is traveling to the left through unknown media at 1.875×10^8 m/s and has a frequency of 5.455×10^{14} Hz. (light in a vacuum has a speed of 3×10^8 m/s). A second wave is mutually coherent with the first wave and has a phase difference of 120 deg. The amplitudes of both waves are 5 (arbitrary units).

a) **(1 point)** What is the index of refraction of the media through which the light is propagating?

b) **(1 point)** What is the wavelength of the light in the unknown media?

c) **(1 point)** What is the wavelength of the light in a vacuum?

d) **(4 points)** Fill in the appropriate numbers for the wave equation for each of the waves [in radians].

$$E_1 = \_\_\_\_\_ \times \sin(\_\_\_\_\_ x - \_\_\_\_\_ t + \_\_\_\_\_)$$

$$E_2 = \_\_\_\_\_ \times \sin(\_\_\_\_\_ x - \_\_\_\_\_ t + \_\_\_\_\_)$$

e) **(2 points)** What is the intensity of the coherent sum of these two waves?

3. **(3 points)** Calculate the rectangular aperture size that will produce a diffraction pattern with 600 nm light whose central spot has an angular width (measured between the first minima on either side of the central spot) of 3 degrees and an angular height of 2 degrees.

4**. (3 points)** You form a real image of two 550 nm point sources through a diffraction-limited lens. The object distance is -10 m and the image distance is 10 m. You find that when the sources are closer than 1 cm, then they are no longer resolved in the image. What is the size of the lens (ie the diameter of the aperture)?

5. **(5 points total)** You are designing an antireflection coating to minimize the reflection of 550 nm light from a diamond (index of refraction = 2.61).

a) **(1 point)** What is the most appropriate index of refraction for the coating?

b) **(1 point)** What is the thickness of the coating?

c) **(1 point)** What is the reflectance of the surface for 550 nm light with the ideal coating applied?

d) **(1 point)** If your only choice for the coating was MgF_2 (n=1.38), what would the thickness have to be?

e) **(1 point)** How thick would you make the MgF_2 coating to maximize, rather than minimize the reflection of 550 nm light?

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6. **(5 points total)** Interference fringes from Young's double slit aperture are generated with a slit separation of 1 mm, a wavelength of 600 nm and an aperture to screen distance of 2 m.

a) **(2 points)** What is the spacing between two adjacent peaks in the interference pattern?

b) **(3 points)** What would the spacing between two adjacent peaks in the interference pattern be if you placed a -2 D thin lens 50 cm from the slit apertures (between the slit apertures and the screen)?

7. **(5 points total)** Consider two equal-amplitude waves of 600 nm light that are mutually coherent.

(3 points) What would be the phase difference between the waves if the second wave was delayed by a distance of 200 nm?

a) In waves?_____

b) In degrees?_____

c) In radians?_____

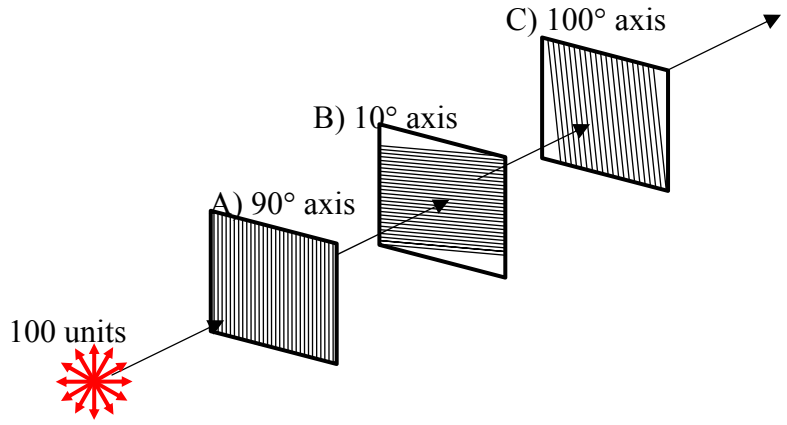
d) **(2 points)** What would be the thickness of thin film reflective coating of index 1.38 that would produce such a phase difference?

8. **(6 points total)** A light wave is described with the following equation:

$$E = 10\sin\left(1.5708\times10^{7}x - 3.1416\times10^{15}t + \pi/4\right)$$

a) **(1 point)** What is the wavelength in nanometers?
b) **(1 point)** What is the initial phase in radians?
c) **(1 point)** What is the angular frequency in radians/sec?
d) **(1 point)** What is the velocity of the wave in meters/sec?
e) **(1 point)** What is the intensity of this wave?
f) **(1 point)** What is the index of refraction of the medium through which this wave is propagating?

9. **(3 points)** Determine the number of units and the orientation of the polarization of the light that emerges from the sequence of polarizers, A B and C shown below. The axis defines the transmission axis.



10. **(2 points)** What order of the above filters will provide the maximum transmitted intensity for unpolarized incident light? NOTE: Reversing the order of the filters will not change the amount of light that is transmitted.

a) ABC (or CBA)
b) ACB (or BCA)
c) BAC (or CAB)

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11. **(4 points)** Design an achromatic doublet comprised of dense flint glass (refractive efficiency = 36.6) and polycarbonate (refractive efficiency = 30.0) that has a power of –5.00 D.

12. **(3 points total)** You have a convex, single-refracting surface made of special glass that has indices of refraction n_D = 1.5, n_F=1.51 and n_C=1.495 and whose radius of curvature is +5.00 cm.

a) **(1 point)** What is the nominal power of the single refracting surface?

b) **(1 point)** What is the refractive efficiency of the glass? (If you do not know how to solve this part, then assume a refractive efficiency of 30.00 and continue to the next part. NOTE: 30.00 is not the correct answer!)

c) **(1 point)** What is the chromatic aberration of the lens?

Answers:

1. diffraction, aberrations

2.a) 1.6; b) 344 nm; c) 550 nm; d) 5 x sin (18,265,073x – (-3.427X10^{15})t+0), 5 x sin (18,265,073x – (-3.427X10^{15})t+2π/3); e) 25

3. 22.9 microns wide, 34.4 microns high

4. aperture = 0.671 mm

5. a) 1.61; b) t= 85 nm; c) 0%; d) t=99.64 nm; e) t = 200 nm

6. a) 1.2 mm; b) 2.1 mm

7. a) 1/3; b) 120; c) 2π/3

8. a) 400; b) p/4; c) 3.1416 x 10^{15}; d) 2 x 10^{8} m/s; e) 100; n= 1.5

9. 0

10. BAC (all other options produce 0 units)