Exam 3--PHYS 2021M-Spring 2009

Multiple Choice
Identify the choice that best completes the statement or answers the question. Each question is worth 2 points.

1. Images made by mirrors are affected by which of these aberrations?
   I. spherical aberration
   II. chromatic aberration
   III. mirages
   IV. photographic aberration
   a. I
   b. I & IV
   c. II
   d. I & II
   e. All of these

2. The human eye consists of a converging lens (the eye lens & cornea) and a “screen” at the back of the eyeball where the real image is formed (the retina). The focal length of the eye lens is changed by the muscles in the eye. Consider that your eye is initially focusing on a very distant object. How does the focal length of the eye lens change when you focus on something much closer? (Assume the distance between the eye lens and retina are the same.)
   a. focal length stays the same
   b. focal length increases
   c. focal length decreases
   d. depends on the index of refraction of the fluid in the eye

3. Which of these four rays is drawn incorrectly for this lens?
   a. a
   b. b
   c. c
   d. d
   e. All are correct
4. In this image the smiley face sees an image of the heart in a flat mirror. Where does Smiley see the image of the heart?

- a. a
- b. b
- c. c
- d. d
- e. none of these

5. Which of these mirrors will produce a virtual image under particular conditions?

- I. Concave
- II. Convex
- III. Flat

- a. II
- b. II & III
- c. I
- d. I, II, & III
- e. I & II

6. In a Young’s double-slit interference apparatus, by what factor is the angle between adjacent light and dark fringes changed when the separation between slits is doubled? (Assume the small angle approximation: \( \sin \theta \approx \theta \))

- a. 1/2
- b. 1
- c. 2
- d. 1/4
7. Waves from a radio station with a wavelength of 600 m arrive at a home receiver a distance 50 km away from the transmitter by two paths. One is a direct-line path (the grey line in this figure) and the second by reflection from a mountain directly behind the receiver (the black line). What is the minimum distance between the mountain and receiver such that destructive interference occurs at the location of the listener? Assume no phase change on reflection.

- a. 600 m
- b. 300 m
- c. 450 m
- d. 150 m

8. This figure shows an interference pattern produced in the double slit experiment. What is the path-length difference of the 2 waves that formed the bright fringe as indicated by the arrow?

- a. $1\frac{1}{2}\lambda$
- b. $2\frac{1}{2}\lambda$
- c. $2\lambda$
- d. $3\lambda$
- e. $1\lambda$
9. Consider the superposition of these 2 waves. Which of the choices represents the interference pattern?

![Wave Patterns]

a.  

b.  

c.  

d.  

10. Two waves are initially in phase and have a wavelength of 0.5 m. One wave travels 3 m, and another wave travels 4.25 meters. What is seen when the 2 waves recombine?

a. a dark spot  

b. not enough information  

c. a bright spot  

d. a grey spot (neither dark nor bright)
Problem: Choose 4 of the following 5 problems. Place a large “X” on the page of the problem that you don’t want graded. Each problem is worth 20 points.

11. In this figure, a light wave along ray $r_1$ reflects once from a mirror and a light wave along ray $r_2$ reflects three times from that same mirror and twice from 2 mirrors at a distance $L$ from the big mirror.

a) What is the smallest value of $L$ that puts the final light waves exactly out of phase?

b) With the small mirrors at that value of $L$, how far must it be moved away from the bigger mirror to again put the final waves out of phase?
12. A concave shaving mirror has a radius of curvature of 25 cm. It is positions so that the (upright) image of a man’s face is 3 times the size of the face. How far is the mirror from the face?
13. This figure shows the basic structure of the human eye. Light refracts into the eye through the cornea and is then further redirected by a lens whose shape (and thus ability to focus the light) is controlled by the muscles. We can treat the cornea and eye lens as a single effective thin lens (part b of the figure). A “normal eye can focus parallel light rays from a distant object O to a point on the retina at the back of the eye, where processing of the visual information begins. As an object is brought close to the eye, however, the muscles must change the shape of the lens so that rays form an inverted real image on the retina. (part c of the figure)

a) Suppose that for figure b, the focal length of the lens is 3 cm. What is the focal length of the lens for an object that is at a distance of 1 meter (as in figure c)?

\[ f' = \] ________________

b) The near point of the human eye is about 25 centimeters; you can’t focus images with an object distance less than 25 cm. What, then, is the minimum radius of curvature that the eye lens can be given by the muscles in the eye?

c = ________________
14. (15 pts) Sunlight is used in a double-slit interference experiment. The fifth-order maximum for a wavelength of 550 nm occurs at an angle of $\theta=90^\circ$. Thus, it is on the verge of being eliminated from the pattern because $\theta$ can’t exceed 90 degrees.

a) What range of wavelengths in the visible range (400-700 nm) are not present in the fourth order maxima.

To eliminate all of the visible light in the fourth-order maximum, (b) should the slit separation be increased or decreased and (c) what least change in separation is needed?
15. Monochromatic light of wavelength 540 nm is incident on a narrow slit. On a screen 3 meters away, the distance between the second diffraction minimum and the central maximum is 2.0 cm.

a) What is the angle of diffraction (θ) of the second minimum?

b) What is the width of the slit?
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Answer Section

MULTIPLE CHOICE

1. ANS: A  PTS: 1
2. ANS: C  PTS: 1
3. ANS: D  PTS: 1
4. ANS: B  PTS: 1
5. ANS: D  PTS: 1
6. ANS: A  PTS: 1
7. ANS: D  PTS: 1
8. ANS: C  PTS: 1
9. ANS: C  PTS: 1
10. ANS: A  PTS: 1

PROBLEM

11. ANS: 
   PTS: 1
12. ANS: 
   PTS: 1
13. ANS: 
   PTS: 1
14. ANS: 
   PTS: 1
15. ANS: 
   PTS: 1