MC 556 problems 45 Eq = 100 Eq

Physics 212, Spring 2009
Quiz 2, Form: A

Name: Key
Date: _____

material	speed of light
vacuum	$c = 3 \times 10^8$ m/s
air	$v \approx c$
water	$0.75c$
glass	$0.66c$

Table 1: Speed of light in a few common materials.

Section 1. Multiple Choice

1. A biconcave spherical lens has a focal length of magnitude 0.27 m. Find the distance to the image of an object 0.54 m from the lens.

   (a) +0.54 m
   (b) +0.18 m
   (c) −0.54 m
   (d) −0.27 m
   (e) −0.18 m

$f = -0.27$ m
$s_i = ?$
$s_o = 0.54$ m

$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$

$\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o}$

$= \frac{-1}{0.27} - \frac{1}{0.54}$

$= -5.56$

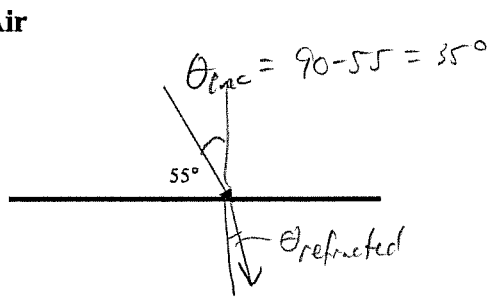
$s_i = \frac{1}{-5.56} = -0.18$ m

2. A biconvex lens produces an image of an object that is half the size of the object. What is the (linear) magnification of the lens in this case?

   (a) -1.5
   (b) 1.5
   (c) -0.5
   (d) 0.5

$M = \frac{h_i}{h_o} = -0.5$

3. Light travels from air to vegetable oil ($n = 1.47$) at an angle of 55° with respect to the interface as shown below.



At what angle, with respect to the normal, does the light travel through the vegetable oil?

   (a) 37°
   (b) 67°
   (c) 57°
   (d) 34°
   (e) 23°

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1 \sin(35) = 1.47 \sin\theta_2$

$\sin\theta_2 = 0.39$

$\theta_2 = \sin^{-1}(0.39) = 23°$

4. Suppose that you watch an object come toward you and you constantly keep the object "in focus." As the object distance decreases, the focal length of your eye

   (a) increases.
   (b) decreases.
   (c) remains constant.

$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$

$\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o}$ so f de

s_i stays same; s_o dec; f inc.

$f \approx 2.5$ for relaxed eye (far pt.)
$f \approx 2.27$ for object at near pt.

5. For the case described in the previous question, as the object distance decreases, the image distance from the lens of your eye to the retina

(a) increases.
(b) decreases.
(c) remains constant.

6. The image formed on the retina, in the previous question, is

(a) real and upright
(b) real and inverted
(c) virtual and upright
(d) virtual and inverted

7. Suppose that in lab, you set up a biconvex lens with focal length 10 cm, and you place the object at a distance of 12 cm. The resulting image is

(a) virtual, upright, and enlarged
(b) virtual, upright, and reduced
(c) real, inverted, and reduced
(d) real, inverted, and enlarged
(e) real, upright, and reduced

8. Light is transmitted through fiber optic cable because of total internal reflection. Suppose that an optical fiber has an index of refraction of 1.46. What is the critical angle (i.e. incident angle), at which light will refract at 90° for light traveling from the optical fiber to air?

(a) 90°
(b) 28°
(c) 1.46°
(d) 22°
(e) 43°

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_1 \sin\theta_1 = 1 \sin(90^\circ)$

$1.46 \sin\theta_1 = 1$

$\theta_1 = 43^\circ$

9. A normal, healthy eye has an image distance (from the lens to the retina) of 2.50 cm. The near point of a normal, healthy eye is 25.0 cm. What is the focal length of the eye when it focuses on an object at the near point?

(a) 2.50 cm
(b) 25.0 cm
(c) 2.12 cm
(d) 2.27 cm
(e) 22.5 cm

$s_i = 2.5\,cm$

$s_o = 25\,cm$

$f = ?$

$\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i} = 0.44$

$f = \frac{1}{0.44} = 2.27\,cm$

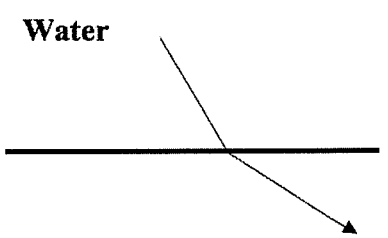
10. As light travels from air to glass, which of the following quantities decreases?

(a) wavelength
(b) frequency
(c) speed
(d) both speed and wavelength
(e) both speed and frequency

11. As light travels from air to glass, which of the following quantities stays the same?

(a) wavelength
(b) frequency
(c) speed
(d) both wavelength and frequency
(e) both speed and frequency

12. A transmitted ray travels from water to another medium as shown below. Which statement about the index of refraction of the medium is true?



(a) $n_A = n_{water}$
(b) $n_A > n_{water}$
(c) $n_A < n_{water}$

note: the ray bends away from the normal

13. What is the index of refraction of glass? (Note: calculate the index of refraction by using the speed of light in glass given in the table.)

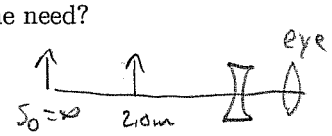
(a) 0.66
(b) 0.33
(c) 1.5
(d) 1.33
(e) 1.66

$n = \frac{c}{v} = \frac{c}{0.66c}$

$= \frac{1}{0.66} = 1.5$

14. A person who is nearsighted has a far point of 2.0 m. If the distance from the corrective lens to her eye is negligible in this case, what focal length lens does she need?

(a) −2.0 m
(b) −1.0 m
(c) −0.02 m
(d) +2.0 m
(e) +4.0 m



$S_i = -2\,m$
$S_o = \infty$

$\frac{1}{f} + \frac{1}{S_i} = \frac{1}{f}$

$\frac{1}{\infty} + \frac{1}{S_i} = \frac{1}{f}$

$S_i = f$

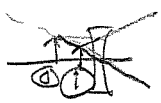
$f = -2\,m$

15. An optometrist prescribes a corrective lens of refractive power 2 D (i.e. 2 diopters). This lens is for a person who is

Note: f is + which is a converging lens

(a) nearsighted.
(b) farsighted.

16. An image formed by a biconcave lens is always



(a) real, upright and reduced.
(b) real, upright and enlarged.
(c) real, inverted and enlarged.
(d) virtual, upright, and reduced
(e) virtual, inverted, and reduced

17. The index of refraction of a medium depends on the frequency of the light traveling through the medium. Thus, if white light is incident on glass or water, for example, then the colors that make up the white light will bend different amounts, causing a spectrum (i.e. rainbow). Which color of light will bend the most when traveling from air to water?

(a) red
(b) orange
(c) green
(d) blue
(e) violet

$n_{violet} > n_{red}$

18. Suppose that the image formed by the lens of a camera is "out of focus." What actually happens in a camera to bring the image "into focus"?

(a) The lens is moved backward or forward, which adjusts both the object distance and image distance until the image distance is the same as the distance between the lens and the CCD or film.
(b) The CCD or film is moved backward or forward until it is at the same distance from the lens as the image distance.
(c) The focal length of the lens is increased or decreased until the image distance is the same as the distance from the lens to the CCD or film.
(d) The object is moved forward or backward, which adjusts the object distance until the image distance is the same as the distance between the lens and the CCD or film.

19. As a ray of light travels from water ($n = 1.3$) to glass at a non-zero angle of incidence, it will bend

$n_{glass} > n_{water}$

(a) toward the normal
(b) away from the normal
(c) None of the above, because it will be transmitted without refracting
(d) None of the above, because it will only reflect and will not transmit

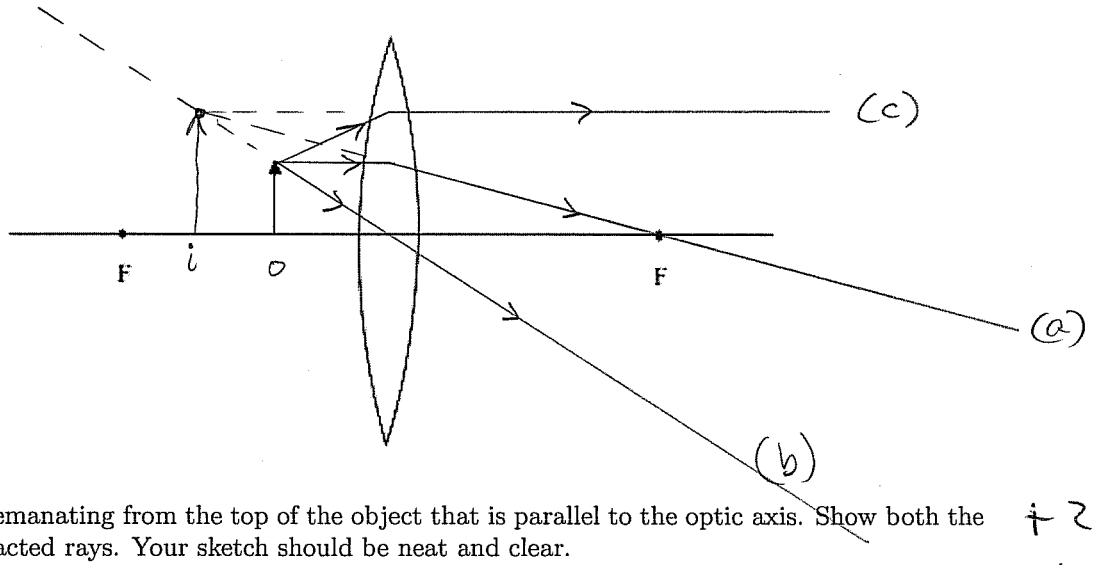
20. For a magnifying class, the object distance should be

(a) less than the focal length of the lens.
(b) greater than the focal length of the lens, but less than twice the focal length of the lens.
(c) greater than twice the focal length of the lens.

produces an enlarged, virtual, upright image.

Section 2. Problem Solving

21. A biconvex lens of focal length 10 cm is shown below. The object is 5 cm from the center of the lens.



(a) Sketch a ray emanating from the top of the object that is parallel to the optic axis. Show both the incident and refracted rays. Your sketch should be neat and clear. +2

(b) Sketch a ray emanating from the top of the object that is incident on the center of the lens. Show both the incident and refracted rays. Your sketch should be neat and clear. +2

(c) Sketch a ray emanating from the top of the object that emerges from the lens parallel to the optic axis. Sketch both the incident and refracted rays. Your sketch should be neat and clear. +2

(d) Sketch the image of the object. +2

(e) Calculate the image distance.

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} \qquad +4$$

$$\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o} = \frac{1}{10} - \frac{1}{5} = -\frac{1}{10}$$

$s_i = -10$ cm virtual image (on same side of object)

(Note: picture is slightly off because object was not drawn at 5 cm dist

(f) Is the image real or (virtual) (circle one); is it inverted or (upright) (circle one), reduced or enlarged (circle one). Explain each of your answers.

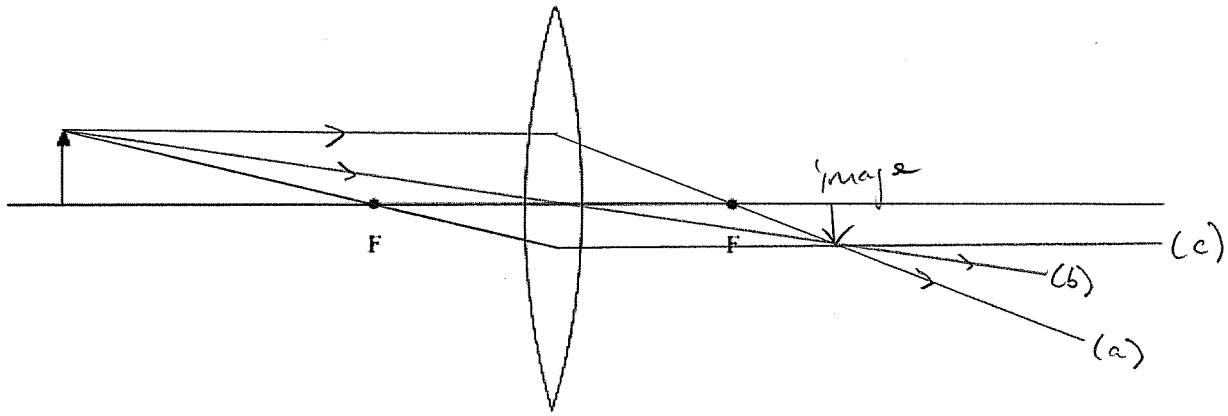
virtual: s_i is − and (image) is on the same side of lens as the object. +3

upright: $M = -\frac{s_i}{s_o} = -\frac{(-10)}{5} = 2 = \frac{h_i}{h_o}$ M is + so h_i is +.

enlarged: $|M| > 1$ so $h_i > h_o$

15

22. A biconvex lens of focal length 10 cm is shown below. The object is 25 cm from the center of the lens.



(a) Sketch a ray emanating from the top of the object that is parallel to the optic axis. Show both the incident and refracted rays. Your sketch should be neat and clear. +2

(b) Sketch a ray emanating from the top of the object that is incident on the center of the lens. Show both the incident and refracted rays. Your sketch should be neat and clear. +2

(c) Sketch a ray emanating from the top of the object that emerges from the lens parallel to the optic axis. Sketch both the incident and refracted rays. Your sketch should be neat and clear. +2

(d) Sketch the image of the object. +2

(e) Calculate the image distance.

$$\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$$

$$\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o}$$

$$= \frac{1}{10} - \frac{1}{25}$$

$$s_i = 16.7 \text{ cm}$$

$$M = \frac{-s_i}{s_o} = \frac{-16.7}{25} = -0.7$$

+4

(f) Is the image ~~real or virtual~~ (circle one); is it inverted or upright (circle one), reduced or enlarged (circle one). Explain each of your answers.

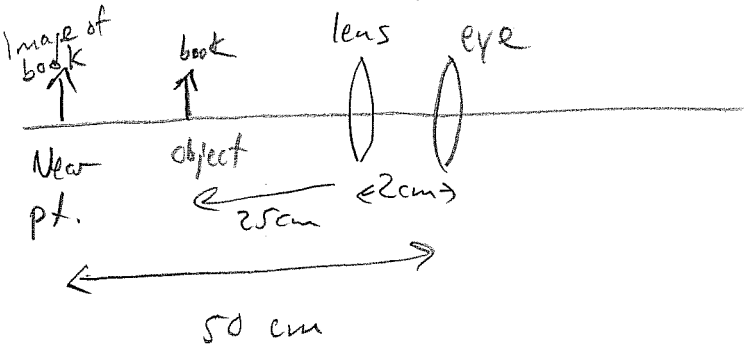
real: s_i is +, it is formed by converging rays, and it is on the opposite side of lens as object.

inverted: M is −, thus h_i is − and image must be inverted.

reduced: $M < 1$ so $h_i < h_o$ +3

15

23. A person can just barely read a book when it is held out at arms length (50 cm from his eye). What power of reading glasses should be prescribed for him if he wants to read a book at 25 cm from his glasses? Assume that his glasses (i.e. the corrective lens) is 2 cm from his eye.



+5

$S_o = 25\text{ cm}$ (book)

$S_i = -48\text{ cm}$ (virtual image created by the lens) at 48 cm from the lens +5

$f = ?$

$$\frac{1}{S_o} + \frac{1}{S_i} = \frac{1}{f}$$

$$\frac{1}{25} + \frac{1}{-48} = \frac{1}{f}$$

Note: f is + so it is a converging lens

$$f = 52\text{ cm} = 0.52\text{ m}$$

+5

$$\text{Power} = \frac{1}{f} = \frac{1}{0.52} = \boxed{1.9\text{ D}}$$

15