Physics 1520, Spring 2013
Quiz 2, Form: A

Name: Key

Date: _____

Section 1. Exercises

1. The index of refraction of a certain type of glass for red light is 1.52. For violet light, it is 1.54. Which color of light, red or violet, travels *slower* in glass.

$v = \frac{c}{n}$ $\quad v \propto \frac{1}{n}$

higher n, slower speed

   (a) red
   (b) violet
   (c) neither; they travel at the same speed.

2. Red light of wavelength 650 nm (in air) travels through glass of index of refraction 1.5. What is the light's frequency in the glass?

f is same in glass as in vacuum

$f = \frac{c}{\lambda} = \frac{3\times10^{8}\ \frac{m}{s}}{650\times10^{-9}\ m} = 4.6\times10^{14}\ Hz$

   (a) 3.1×10^{14} Hz
   (b) 6.9×10^{14} Hz
   (c) 2.1×10^{14} Hz
   (d) 4.6×10^{14} Hz

3. Green laser light shines on a double slit, creating a pattern of bright and dark spots on a screen some distance away. Which one of the following changes, carried out separately, would *increase* the distance between the bright spots on the screen?

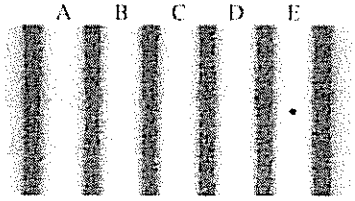
red is longer λ than green

$\Delta y = \frac{\lambda L}{d}$ $\quad \Delta y \propto \lambda$

so longer λ, larger Δy

   (a) Replace the green laser with a red laser.
   (b) Replace the green laser with a blue laser.
   (c) Increase the spacing between the slits.
   (d) Decrease the distance between the double slit and the screen.

4. Light passes through two slits and produces the interference pattern shown below. The distance between fringe A and fringe E in the picture is 1.0 cm. What is the fringe spacing, Δy?



5 fringes, 4 "spaces"

$\Delta y = \frac{1.0\ cm}{5-1} = \frac{1.0\ cm}{4}$

$= 0.25\ cm$

   (a) 4.0 cm
   (b) 1.0 cm
   (c) 0.50 cm
   (d) 0.25 cm
   (e) 0.20 cm

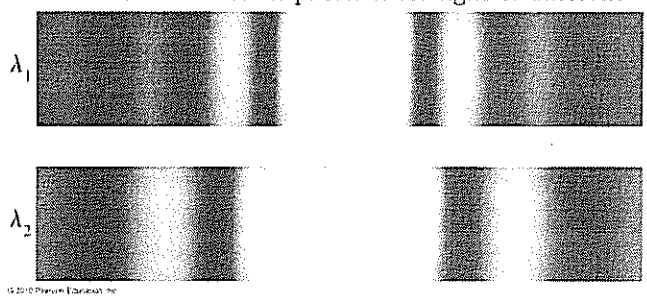
5. Light from a helium-neon laser ($\lambda = 633$ nm) is used to illuminate two narrow slits. The interference pattern is observed on a screen 3.0 m behind the slits. Adjacent fringes are 4 mm apart. How far apart are the two slits?

(a) 7.60×10^{-4} m
(b) 7.60×10^{-9} m
(c) 475 m
(d) 4.75×10^{-7} m
(e) 4.75×10^{-4} m

$L = 3m$
$\Delta y = 4 \times 10^{-3} m$
$\lambda = 633 \times 10^{-9} m$
$d = ?$

$\Delta y = \frac{\lambda L}{d}$
$d = \frac{\lambda L}{\Delta y} = 4.75 \times 10^{-4} m$

6. Two different diffraction patterns for light of different wavelengths are shown below.

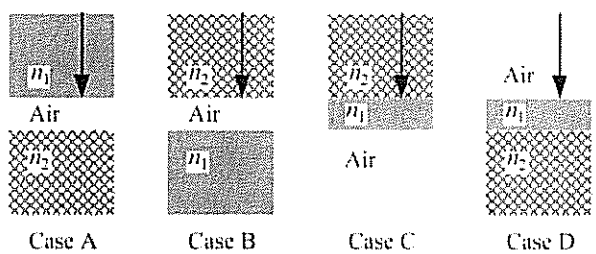


Single-slit diffraction pattern

How was each pattern created?

(a) In both cases, light passed through 2 slits.
(b) In both cases, light passed through 1 slit.

Questions 7–8: The figure shows four situations in which light is incident perpendicularly on a thin film (the middle layer in each case). The indices of refraction are $n_1 = 1.50$ and $n_2 = 2.00$. Air is also one of the layers in each case.



$n_1 >$ air so in Case A, no phase change at top surface.
air $< n_2$ (in Case A) so 1 phase change at bottom surface.

7. For the two reflected rays (off the top surface of the film and the bottom surface of the film) in Case A, there is a total of

(a) 0 phase changes
(b) 1 phase change
(c) 2 phase changes

8. In Case D above, there are 2 total phase changes for light reflected from the top and bottom surfaces of the film, and the film's thickness is 153 nm. Which one of these wavelengths of light will constructively interfere for this thickness?

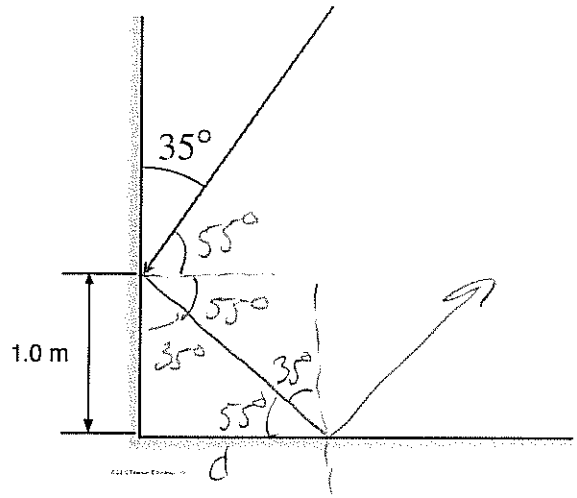
(a) 612 nm
(b) 410 nm
(c) 459 nm
(d) 579 nm
(e) 536 nm

$2t = \frac{m\lambda}{n}$
$\lambda = \frac{2tn}{m}$

$n = 1.5$, $m = 1$
$t = 153nm$

$= \frac{2}{1}(153nm)(1.5) = \boxed{459nm}$

Questions 9–10: Two plane mirrors are at a 90° angle. Light is incident on the side mirror as shown below.



9. At what distance from the side mirror does the ray hit the bottom mirror?

(a) 1.4 m
(b) 0.57 m
(c) 1.0 m
(d) 0.82 m
(e) 0.70 m

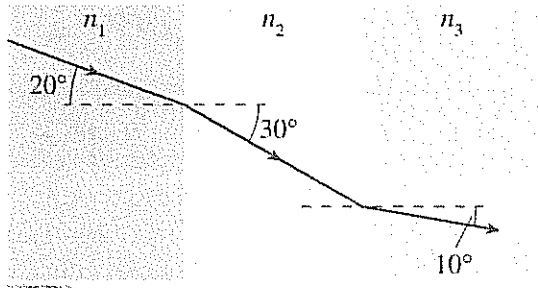
$\tan(35^\circ) = \frac{d}{1m}$

$d = \tan(35^\circ) = 0.7m$

10. At what angle, with respect to the normal, does the ray hit the bottom mirror?

(a) $\theta < 35°$
(b) $35°$
(c) $35° < \theta < 55°$
(d) $55°$
(e) $\theta > 55°$

Questions 11–12: A ray travels along the path shown below. $n_1 = 2.0$.



11. What is n_2?

(a) 2.2
(b) 1.5
(c) 1.4
(d) 3.9
(e) 1.2

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

$2 \sin(20°) = n_2 \sin(30°)$

$n_2 = 1.37$

12. Which of the following is true?

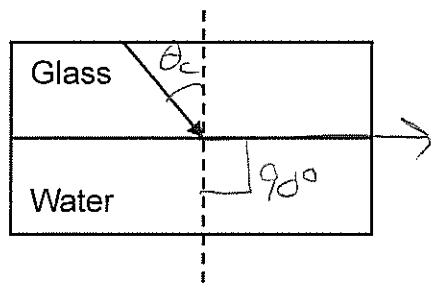
(a) $n_3 = n_1$
(b) $n_3 > n_1$
(c) $n_3 < n_1$
(d) none of the above because it cannot be determined from the given information

$n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3$

$n_1 \sin\theta_1 = n_3 \sin\theta_3$

since $\theta_3 < \theta_1$, $n_3 > n_1$

13. A ray of light is incident on a glass-water interface as shown below. What is the critical angle? ($n_{glass} = 1.5$ and $n_{water} = 1.33$)



$n_1 \sin\theta_c = n_2 \sin(90°)$

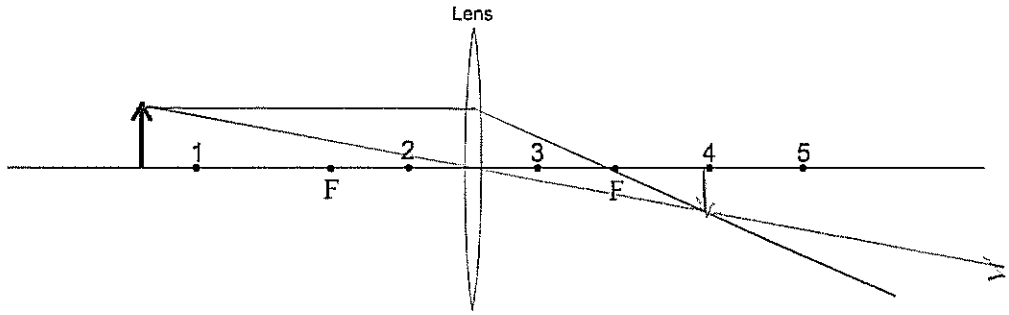
$1.5 \sin\theta_c = 1.33$

$\sin\theta_c = \frac{1.33}{1.5}$

$\theta_c = 62°$

(a) 62°
(b) 49°
(c) 42°
(d) 28°
(e) none of the above because it is impossible for light traveling from glass to water to undergo total internal reflection

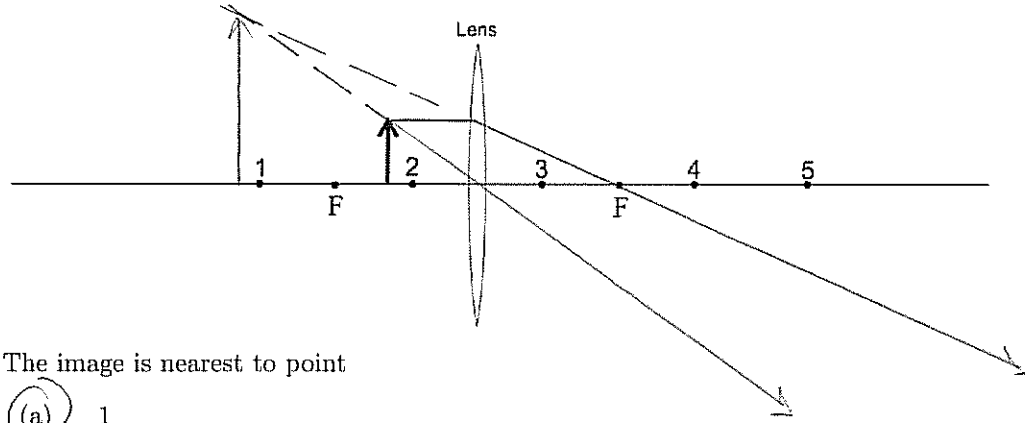
14. Trace the "easy" rays for the object and lens shown below.



The image is nearest to point

(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

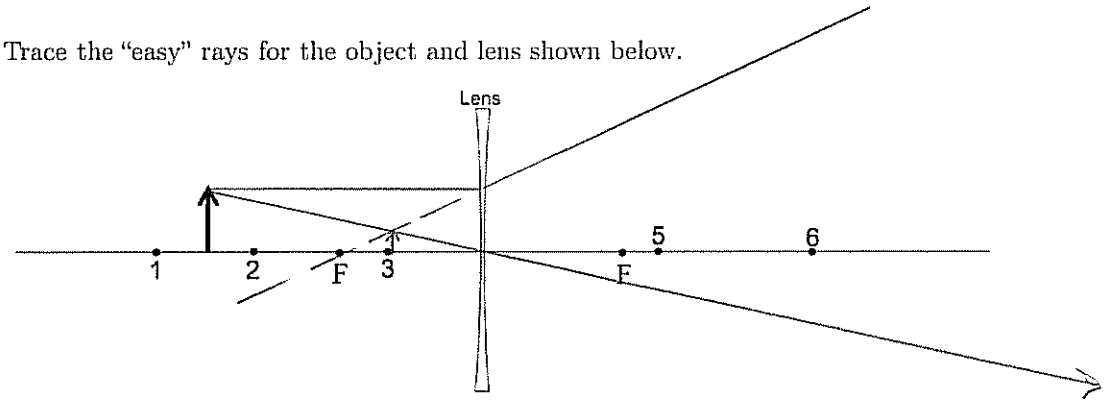
15. Trace the "easy" rays for the object and lens shown below.



The image is nearest to point

(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

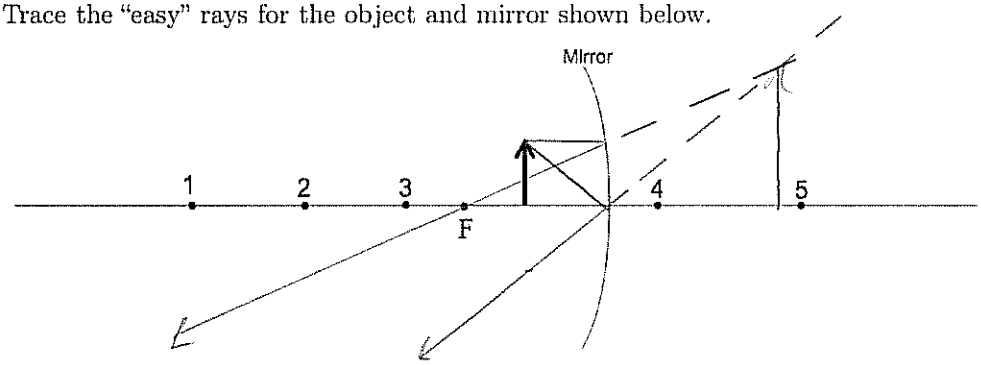
16. Trace the "easy" rays for the object and lens shown below.



The image is nearest to point

(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

17. Trace the "easy" rays for the object and mirror shown below.



The image is nearest to point

(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

Questions 18–19: A dentist uses a curved mirror to view the back side of teeth on the upper jaw. Suppose she wants an upright virtual image with a magnification of 2.0 when the mirror is 1.2 cm from a tooth. (Assume that the object and image are along a straight line.)

18. What is the image distance?

$M = 2.0$

$s = 1.2\text{ cm}$

$M = \frac{-s'}{s}$

$s' = -Ms$

$= -2(1.2\text{cm})$

$= -2.4\text{cm}$

(a) 0.6 cm
(b) 2.4 cm
(c) -0.6 cm
(d) -1.2 cm
(e) -2.4 cm

Note that f is −

19. What is the focal length of the mirror?

So it's a convex mirror.

(a) 0.42 cm
(b) 2.4 cm
(c) 0.8 cm
(d) 1.25 cm
(e) -2.4 cm

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$

$= \frac{1}{1.2\text{cm}} + \frac{1}{-2.4\text{cm}} = \frac{1}{2.4\text{cm}}$

$f = 2.4\text{cm}$

Questions 20–22: A 1.0-cm tall object is 75 cm in front of a converging lens that has a 30 cm focal length.

20. What is the image distance?

$s = 75\text{cm}$
$f = 30\text{ cm}$
$h = 1\text{cm}$
$s' = ?$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

$\frac{1}{s'} = \frac{1}{f} - \frac{1}{s}$

$= \frac{1}{30\text{cm}} - \frac{1}{75\text{cm}} = 0.02$

$s' = \frac{1}{0.02\text{cm}^{-1}} = 50\text{ cm}$

(a) 21 cm
(b) -21 cm
(c) 45 cm
(d) 50 cm
(e) -50 cm

21. Is the image real or virtual?

because s' is +.

(a) real
(b) virtual

22. Calculate the magnification. Is the image reduced or enlarged?

$|m| = \frac{-s'}{s} = \frac{-50\text{cm}}{75\text{cm}} = -0.67$

$|m| < 1$ so reduced

(a) reduced
(b) enlarged
(c) neither because $|m| = 1$

23. A lens used to correct farsighted or nearsighted vision

(a) produces either a virtual image or a real image depending on whether you are farsighted or nearsighted.
(b) always produces a real image.
(c) always produces a virtual image.

Image must be on same side of lens as objects

24. Suppose that a patient is farsighted. Her near point is 150 cm. She would like to be able to focus on objects (like a book) that is at a normal near point is 25 cm. What focal length lens is needed?

lens creates an image at $s' = -150\text{cm}$ ← virtual

$s = 25\text{cm}$

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} = \frac{1}{25\text{cm}} + \frac{1}{-150\text{cm}}$ $f = 30\text{cm}$

(a) -21 cm
(b) -30 cm
(c) 21 cm
(d) 25 cm
(e) 30 cm

25. Lens A has a focal length of 20 cm. Lens B has a focal length of 5 cm. Which lens has a greater refractive power?

$P = \frac{1}{f}$ shorter f has greater P

(a) Lens A
(b) Lens B
(c) Neither, they have the refractive power.