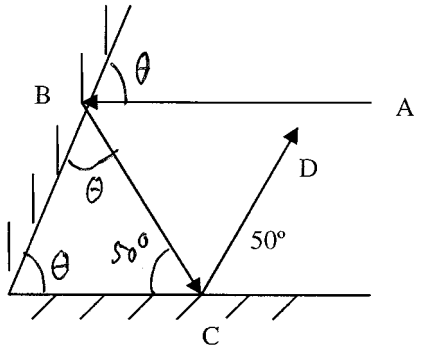
Exam 4 Physics 126 Fall 2008 **Name:**

Time Allowed: 2 Hours
Each question is worth 5 points.
Credits are given for numerical problems only if evidence of calculation is presented.

1. The diagram shows two plane mirrors making an unknown angle with each other. The ray AB is incident on one of the mirrors in a direction **parallel** to the other mirror. After two reflections, it emerges as the ray CD, which makes an angle of 50° with the mirror it comes out of. Find the angle between the mirrors

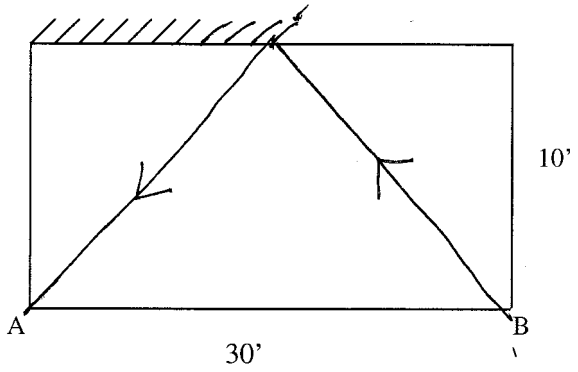


$2\theta + 50^\circ = 360^\circ$

$\theta = \frac{130}{2} = 65^\circ$

(a) 50°
(b) 65°
(c) 70°
(d) 75°

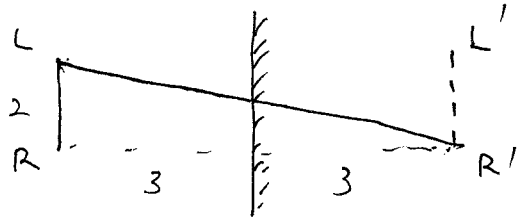
2. As shown in the diagram, a man enters the door at the corner A of a room., and a thief hides in the corner B. There is a mirror on the wall as shown in the shaded area. Given the dimensions of the room as shown, what is the minimum width of the mirror so that the thief can be seen from A? **Draw a ray showing how the thief can be seen.**



(a) 5' (b) 10' (c) 15' (d) 20'

3. A man stands ~~6~~ 3 feet in front of a mirror. The width of his shoulder from left to right is 2 feet. What is the distance between his left shoulder and the left shoulder of his image?

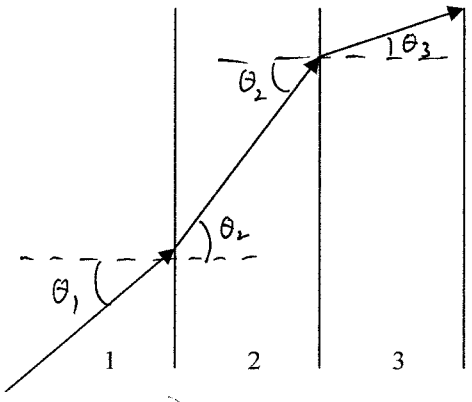
(a) 6.3 feet
(b) 6.0 feet
(c) 3.6 feet
(d) 3.0 feet



left shoulder of image

$LR' = \sqrt{2^2 + 6^2} = \sqrt{40} = 6.3$

4. The figure shows a light ray in three media. What is the correct order for ~~increasing~~ decreasing refractive indices?



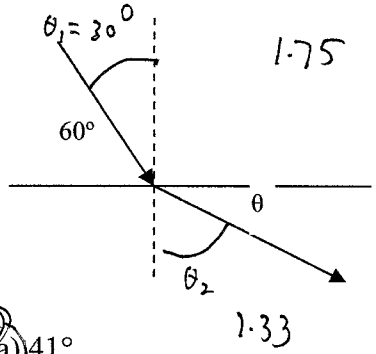
$\theta_2 > \theta_1 > \theta_3$

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

$n_3 > n_1 > n_2$

(a) 1,2,3 (b) 3,1,2 (c) 2,3,1 (d) 3,2,1

5. The figure shows a ray incident from a crystal to water. The refractive index of the crystal is 1.75 and that of water is 1.33. Determine the angle θ as shown.



$1.75 \sin 30^\circ = 1.33 \sin\theta_2$

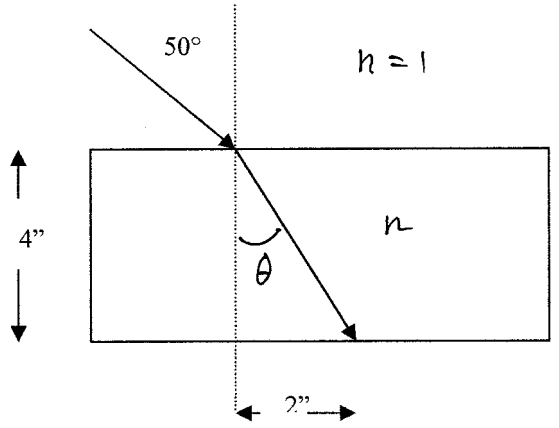
$\sin\theta_2 = \frac{1.75 \sin 30^\circ}{1.33} = 0.658$

$\theta_2 = 41.1^\circ$

$\theta = 90 - \theta_2 = 49^\circ$

(a) 41°
(b) 45°
(c) 49°
(d) 30°

6. The figure shows a light ray from air entering a glass slab at 50° angle of incidence. The thickness of the glass slab is 4 inches, and the point of exit of the ray from the slab is 2 inches away from where the normal for the first refraction intersects the exit surface. Determine the refractive index of the glass.



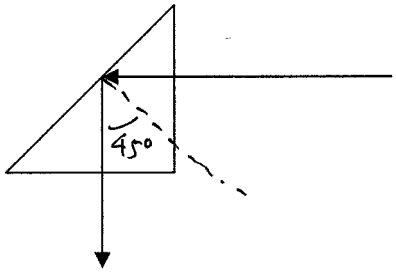
$\theta = \tan^{-1}\frac{2}{4} = 26.6^\circ$

$1 \times \sin 50^\circ = n \sin 26.6^\circ$

$n = \frac{\sin 50^\circ}{\sin 26.6^\circ} = 1.7$

(a) 1.2
(b) 1.4
(c) 1.5
(d) 1.7

7.. Light rays entering a 45° glass prism from air as shown are found to be completely deflected through 90°. Which of the following statements regarding the refractive index n of the glass must necessarily be true?



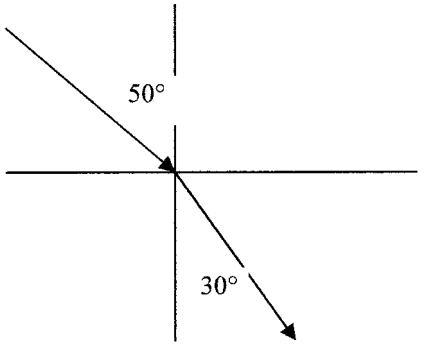
Critical angle of total internal reflection $\theta_c \leq 45^\circ$

From $1 \times \sin 90^\circ = n \sin\theta_c$

$n = \frac{1}{\sin\theta_c} \geq \frac{1}{\sin 45^\circ} = \frac{1}{\frac{\sqrt{2}}{2}} = \sqrt{2} = 1.41$

(a) $n \geq 1.50$
(b) $1.50 > n \geq 1.41$
(c) $n \geq 1.41$
(d) $n < 1.41$

8. The diagram shows a light ray from air undergoing refraction into another medium. With the angles of incidence and refraction as shown, determine the speed of light in the medium. (The speed of light in air is 3.0×10^8 m/s.)



$1 \times \sin 50^\circ = n \sin 30^\circ$

$n = \frac{\sin 50^\circ}{\sin 30^\circ} = 1.53$

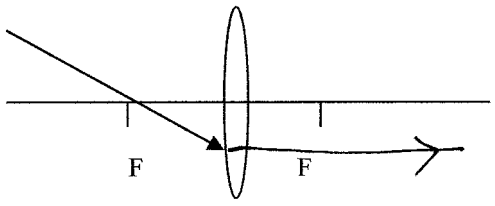
$c_{medium} = \frac{c_{vacuum}}{n}$

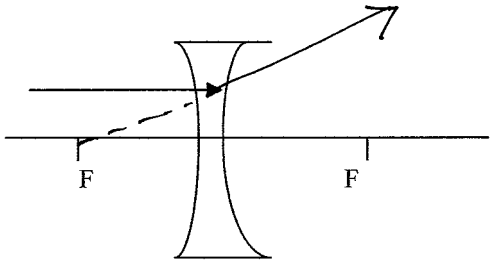
$= 1.96\times10^8$

$= 2.0\times10^8$ m/s

(a) 2.0×10^8 m/s
(b) 2.3×10^8 m/s
(c) 2.8×10^8 m/s
(d) 3.0×10^8 m/s

9. Complete the rays in the following two diagrams for thin lenses with their focal points identified.





10. A 3.0-cm object is placed 10.0 cm from a thin lens. The resulting image is real and is 15.0 cm from the lens. The focal length of the lens and the size of the image are

(a) 30 cm and 4.5 cm
(b) 30 cm and 2.0 cm
(c) 6.0 cm and 2.0 cm
(d) 6.0 cm and 4.5 cm

$d_o = 10$ cm

$d_i = +15$ cm

$\frac{1}{f} = \frac{1}{10} + \frac{1}{15} = \frac{5}{30}$

$f = 6$ cm

$m = -\frac{d_i}{d_o} = -\frac{15}{10} = -1.5$

$h_i = m h_o = -1.5 \times 3 = -4.5$ cm

11. Find the image distance and magnification by ray tracing on the graph paper provided, with the input data as given: **(NO CALCULATION REQUIRED!!)**

$f = +10cm \quad d_o = 6cm$ if accurate

$d_i = -15cm$ (-15cm) $\quad m = \frac{7.5}{3} = 2.5$

12. The contact lens prescription for Lynda is $-4\,dioptre$. Without the lenses, can she see clearly an object 20cm away? Give reasons.

(a) Yes (b) No

$f = -\frac{1}{4}\ m = -0.25\ m$ concave lens, near-sighted person

far point = 25 cm.

13. The fabled General Guan in ancient China in his old age had to hold a book at least 75 cm away from his eyes to read. Which type of contact lens he could have used and what would be the focal length so that he could hold the book at 25 cm away as a normal person does.

(a) 37.5 cm concave
(b) 37.5 cm convex
(c) 50.0 cm concave
(d) 50.0 cm convex

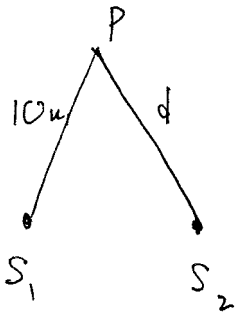
$d_o = 25$ cm

$d_i = -75$ cm

$\frac{1}{f} = \frac{1}{25} - \frac{1}{75} = +\frac{2}{75}$ $\quad f = 37.5$ cm

14. Two loudspeakers S_1 and S_2 oscillating in phase generate sound waves of wavelength 4.0m. It is found that at a point P, which is at a distance of 10m from S_1., no sound can be heard. Which of the following choice is correct for the distance between P and S_2 ?

(a) 14m
(b) 15m
(c) 16m
(d) 17m

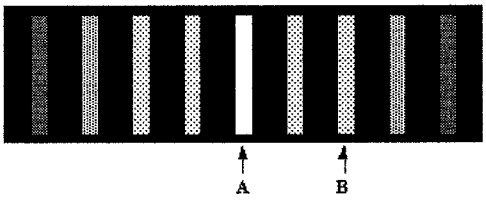


$d - 10 = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$. destructive interference.

$= 2, 6, 10, \ldots$

$d = 12, 16, 20, \ldots$

15. The figure shows the interference pattern produced when light of wavelength 600 nm is incident on two slits. Fringe **A** is equally distant from each slit. By what distance is fringe **B** closer to one slit than the other?

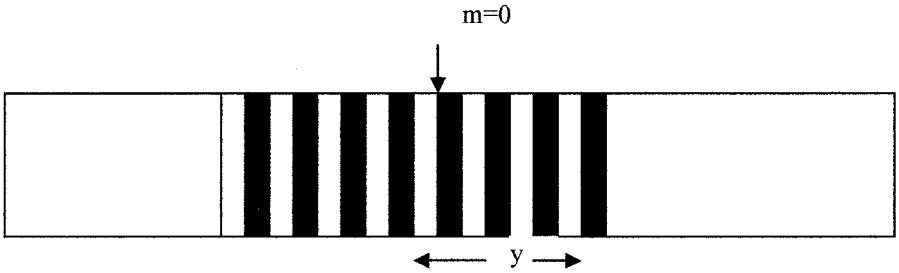


$\ell_B - \ell_A = 2\lambda$

$= 2 \times 600 = 1200$ nm

(a) 600nm
(b) 800nm
(c) 1000nm
(d) 1200nm

16. Light of wavelength 540nm is incident on two slits that are separated by 0.15 mm. The figure shows the resulting interference pattern observed on a screen 2.0 m from the slits. Find the length y indicated, which is the distance between one of the bright fringes and the central bright fringe



(a) 0.7 cm
(b) 1.4 cm
(c) 2.2 cm
(d) 2.9 cm

$\lambda = 540$ nm $= 5.4 \times 10^{-7}$ m $\quad L = 2.0$ m

$d = 0.15$ mm $= 1.5 \times 10^{-4}$ m

$m = 3$

$\theta_m = \frac{m\lambda}{d} = 0.0108$

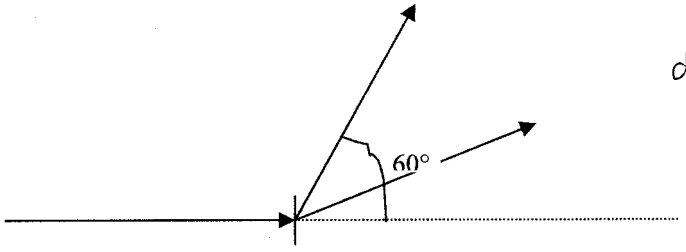
$y_m = L\theta_m = 0.022$ m $= 2.2$ cm

17. In a single slit diffraction experiment, which of the following measures will lead to the most increase in the width of the diffraction pattern on the screen?

(a) Increase the wavelength and reduce the slit width
(b) Increase the wavelength and increase the slit width
(c) Reduce the wavelength and increase the slit width
(d) Reduce the wavelength and reduce the slit width

$\theta_1 = \frac{\lambda}{w}$ half-width of central maximum

18. When monochromatic light is incident on a diffraction grating, brightness is observed in the first two directions away from the normal to the grating aa shown, where the larger angle is 60° with the normal. The grating constant is 8.0×10^5 lines/m. What is the wavelength of the light?



$d = \frac{1}{8\times10^5} = 1.25\times10^{-6}$ m

$m = 2 \qquad \theta_m = 60^\circ$

$d \sin\theta_m = m\lambda$

$\lambda = \frac{d \sin\theta_m}{m} = 5.41\times10^{-7}$ m

(a) 410 nm
(b) 540 nm
(c) 590 nm
(d) 660 nm

19. What is the minimum diameter of the objective of an astronomical telescope that can resolve a 1.0 km wide crater on the moon, using light of wavelength 575nm. (The distance of the moon is 3.85×10^8m.)

(a) 4 cm
(b) 10 cm
(c) 18 cm
(d) 27 cm

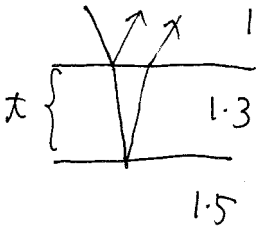
Rayleigh criterion: $\theta = 1.22\frac{\lambda}{D}$

$\theta = \frac{1000}{3.85\times10^8} = 2.6\times10^{-6}$

$D = \frac{1.22\lambda}{\theta} = \frac{1.22\times575\times10^{-9}}{2.6\times10^{-6}} = 0.27$ m

20. An oil film of refractive index 1.3 rests on a glass plate of refractive index 1.5. What is the minimum thickness of the film so that when light of wavelength 660nm in air shines on it directly from the top, the film appears dark when viewed directly from above?

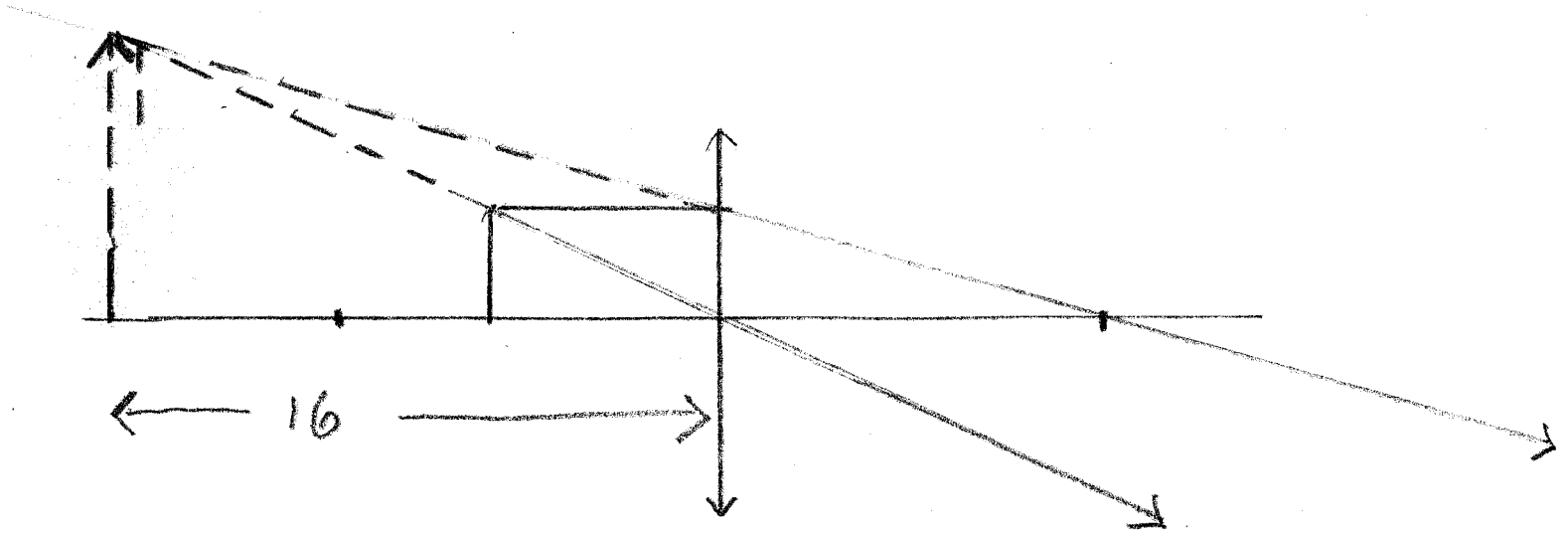
(a) 165 nm
(b) 127 nm
(c) 330 cm
(d) 254 cm



$2t = \frac{\lambda_f}{2}$ (two 180° phase change upon reflection)

$t = \frac{\lambda_f}{4} = \frac{\lambda}{4n} = \frac{660}{4\times1.3} = 127$ nm

#11



$m = \frac{7.5}{3} = 2.5$