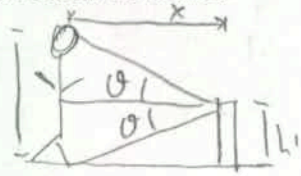
*Closed book. No work needs to be shown for multiple-choice questions.*

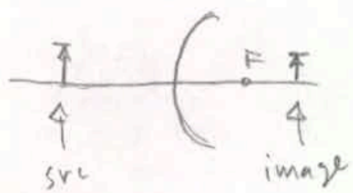
1. If a man wishes to use a plane mirror on a wall to view both his head and his feet as he stands in front of the mirror, the minimum required length of the mirror:

    a. is equal to the height of the man. $h' = h/2$
    b. is equal to one half the height of the man.
    c. depends only on the distance the man stands from the mirror.
    d. depends on both the height of the man and the distance from the man to the mirror.
    e. is equal to one quarter the height of the man.



2. A convex spherical mirror has a radius of curvature of 24 cm. An object is placed 6.0 cm in front of the mirror. The image position is:

    a. 4.0 cm behind the mirror.
    b. 4.0 cm in front of the mirror.
    c. 12 cm behind the mirror.
    d. 12 cm in front of the mirror.
    e. at infinity.



$1/i = 1/f - 1/s \Rightarrow i = \frac{sf}{s-f}$

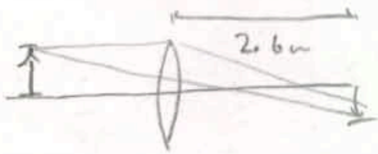
$f = -12\text{cm}$

$i = \frac{-12(6)}{6+12} = -4\text{cm}$ behind

3. You are projecting 35mm slides onto a wall 2.6m from the projector. The projector has a single lens with focal length 12cm. (i) How far should the slides be from the lens? (ii) How big will the image be?

    a. (i) 12.6cm (ii) -72cm
    b. (i) -12.6cm (ii) 72cm
    c. (i) 25cm (ii) 36 cm
    d. (i) 25cm (ii) -36cm
    e. (i) -25cm (ii) 36cm

$h = 35\text{mm}$



$f = +12\text{cm}$, $s = ?$, $i = 2.6\text{m}$

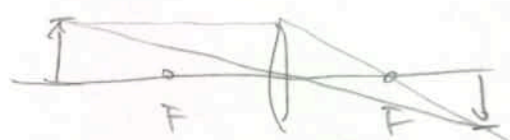
$s = \frac{.12(2.6)}{2.6 - .12} = +12.6\text{cm}$; $M = \frac{-2.6}{0.126} = -20 \Rightarrow$

$h = -20(35)\text{mm} = -72\text{cm}$

4. An object is 30 cm in front of a converging lens of focal length 10 cm. The image is:

    a. real and smaller than the object.
    b. real and the same size as the object.
    c. real and larger than the object.
    d. virtual and the same size as the object.
    e. virtual and smaller than the object.

$f = +10\text{cm}$, $s = 30\text{cm}$



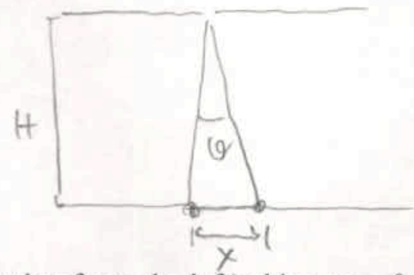
$i = \frac{10(30)}{30-10} = \frac{300}{20} = 15$

$M = -\frac{i}{s} = \frac{-15}{30} = -1/2$

5. The movie "Patriot Games" has a scene in which CIA agents use spy satellites to identify individuals in a terrorist camp. Suppose that a minimum resolution for distinguishing human features is about 5cm. If the spy satellite's optical system is diffraction limited, what diameter mirror or lens is needed to achieve this resolution from an altitude of 100km? Assume a wavelength of 550nm.

Both Answers OK

a. 1000m
b. 100m
c. 10m
d. 1m
e. 0.1m

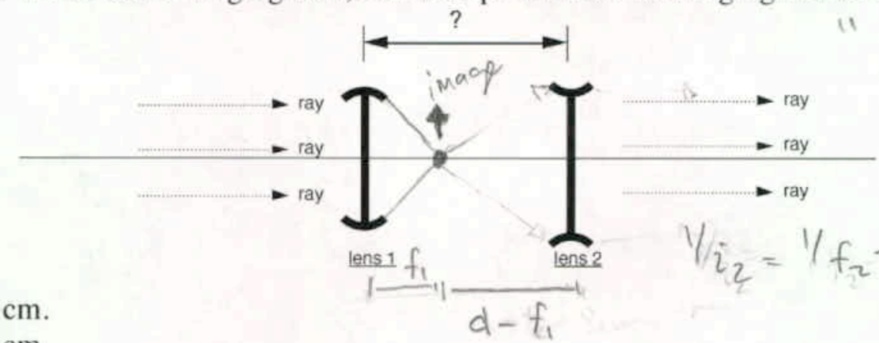



$\tan(\theta) \simeq \theta \simeq \frac{x}{H} = \frac{\lambda}{D}$

$\Rightarrow D = \frac{\lambda H}{x}$

$D = \frac{(550\times10^{-9}m)(100\times10^{3}m)}{(5\times10^{-2}m)} = 11\times10^{3}\times10^{-4} = 11\times10^{-1} = 1.1 m$

6. Parallel light rays (originating from the left) shine on a $f = +15$ cm converging lens (lens 1). To the right of this lens is a $f = -8.0$ cm diverging lens (lens 2). If parallel light rays then exit to the right of the second diverging lens, how far apart are the converging and diverging lenses?




Gaileleo Telescope

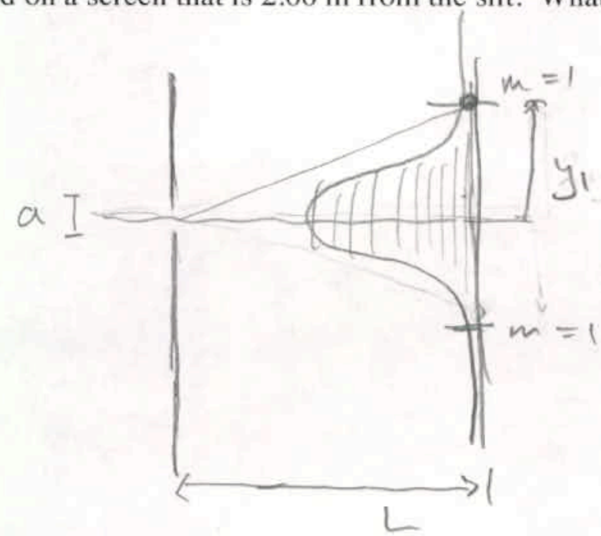
$1/i_2 = 1/f_2 - 1/s_2 = 0$ if $s_2 = f_2 = d - f_1$

a. 17 cm.
b. 15 cm.
c. 1.9 cm.
d. 5.2 cm.
e. 7.0 cm.

Required distance: $d = f_1 + f_2 = 15 - 8 = 7cm$

7. Light of wavelength 540 nm is incident on a single slit of width 0.150 mm, and a diffraction pattern is produced on a screen that is 2.00 m from the slit. What is the width of the central bright fringe?

a. 0.720 cm.
b. 1.76 cm.
c. 2.88 cm.
d. 2.16 cm.
e. 1.44 cm.




single slit minima

$a \sin(\theta) = \lambda m$

m = 1 gives:

$\sin(\theta) = \frac{\lambda}{a} \simeq \frac{y_1}{L}$

$y_1 = L\left(\frac{\lambda}{a}\right)$

$2y_1 = \frac{2L\lambda}{a} = 1.44$

**8**. Light with a wavelength of 450 nm shines through a telescope with a circular aperture diameter of 0.60 cm. Use Rayleigh's criterion to determine the limiting angle of resolution.

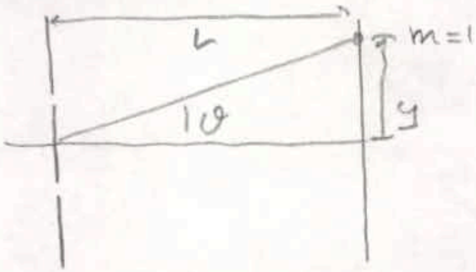
- a. $9.2 \times 10^{-5}$ rad.
- b. $3.0 \times 10^{-9}$ rad.
- c. $1.3 \times 10^{-4}$ rad.
- d. $5.0 \times 10^{-7}$ rad.
- e. $7.5 \times 10^{-5}$ rad.

$\theta = 1.22 \frac{\lambda}{D} = 9.2 \times 10^{-5}$ rad

**9**. You are recreating Young's double-slit experiment in lab with red laser light ($\lambda = 700$ nm) as a source. You perform the experiment once with a slit separation of 4.5 mm and obtain an interference pattern on a screen a distance 3.0 m away. You then change the slit separation to 9.0 mm and perform the experiment again. In order to maintain the same interference pattern spacing as the first experiment, the new screen-to-slit distance should be changed to:

- a. 1.5 meters.
- b. 2.1 meters.
- c. 4.2 meters.
- d. 6.0 meters.
- e. 12 meters.

Keep "y" the same ($y = \frac{Lm\lambda}{d}$)




$y_1 = y_1'$ choose $m=1$,

$\frac{L}{d} = \frac{L'}{d'} \Rightarrow L' = \left(\frac{d'}{d}\right)L$

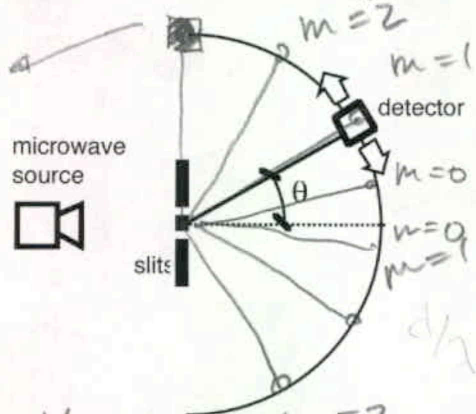
$L' = 2L$

**10**. Coherent microwave light with a frequency $f = 2.0 \times 10^{10}$ Hz is incident on a $d = 5.0$ cm double slit barrier, producing an interference pattern of a number of maxima and minima. A detector is free to swing around the full 180° in order to find the presence of interference maxima and minima. How many different minima will this detector detect, as it is allowed to swing around the full 180°? (Include minima on both sides of the centerline in your count.)

- a. five.
- b. four.
- c. six.
- d. ten.
- e. seven.

$\theta = 90°$

$\lambda = \frac{c}{f} = 0.015$ m




minima seen

double slit minima:

$\sin(\theta) = (m + \frac{1}{2})\frac{\lambda}{d}$ w/ $\lambda/d = 1/3.33$

At $\theta = 90°$, $\sin(90°) = 1 = (m + \frac{1}{2})\frac{1}{3.33} \Rightarrow m = 3.33 - 0.5$

$m = 2.83 = 2$

include m=0 $\Rightarrow$ 3 minima seen from $0 \le \theta \le 90°$

$\Rightarrow$ 6 total for $-90° \le \theta \le 90°$