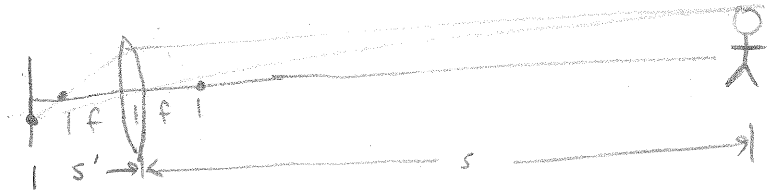
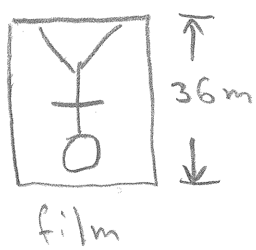
HW 27

34.36 When a camera is focused, the lens is moved away from or toward the film. If you take a picture of your friend, who is standing 3.90 m from the lens, using a camera with a lens with a 85-mm focal length, how far from the film is the lens? Will the whole image of your friend, who is 175 cm tall, fit on film that is 24 × 36 mm?



$$\frac{1}{s'} = \frac{1}{f} - \frac{1}{s} \Rightarrow s' = \frac{1}{\frac{1}{f} - \frac{1}{s}} = \frac{1}{\frac{1}{85\,mm} - \frac{1}{3900\,mm}} \cong \boxed{86.89\ mm}$$

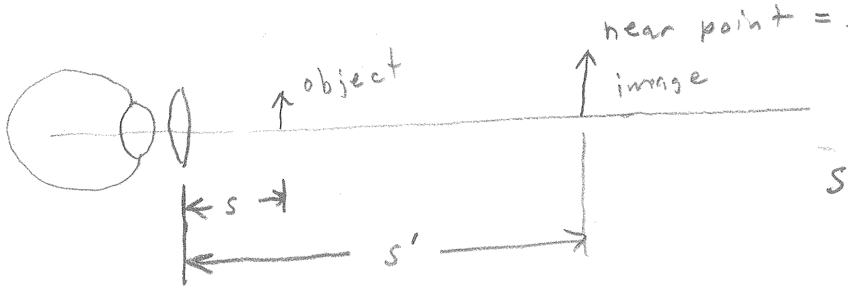


$$\frac{y'}{y} = -\frac{s'}{s} \Rightarrow |y'| = y\,\frac{s'}{s} = (175\,cm)\,\frac{(86.89384\,mm)}{(3900\,mm)}$$

$= 38.99\ mm$ No it will not fit

34.45 a) Where is the near point of an eye for which a contact lens with a power of +2.75 diopters is prescribed? b) Where is the far point of an eye for which a contact lens with a power of −1.30 diopters is prescribed for distant vision?

a)



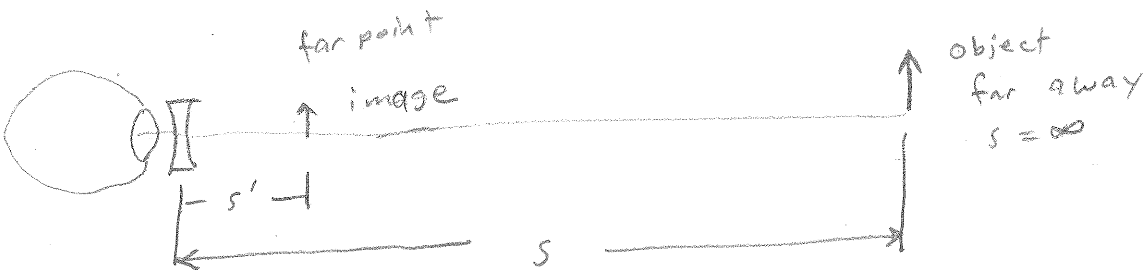
s = corrected near point

= 25 cm

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} \Rightarrow s' = \frac{1}{\frac{1}{f} - \frac{1}{s}} = \frac{1}{\frac{2.75}{m} - \frac{1}{25\,cm}} = \frac{1}{\frac{2.75}{100\,cm} - \frac{1}{25\,cm}}$$

$= -80\,cm$ near point is $\boxed{80\,cm}$ from the eye

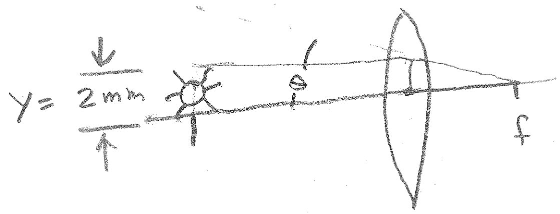
b)

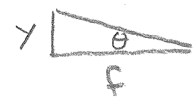


$$s' = \frac{1}{\frac{1}{f} - \frac{1}{s}} = \frac{1}{\frac{1}{f} - \frac{1}{\infty}} = f = \frac{-1}{1.30}\,\frac{m}{1} = -76.92\,cm$$

far point is $\boxed{76.92\,cm}$ from the eye

34.50 You want to view an insect 2.00 mm in length through a magnifier. If the insect is to be at the focal point of the magnifier, what focal length will give the image of the insect an angular size of 0.025 radian?

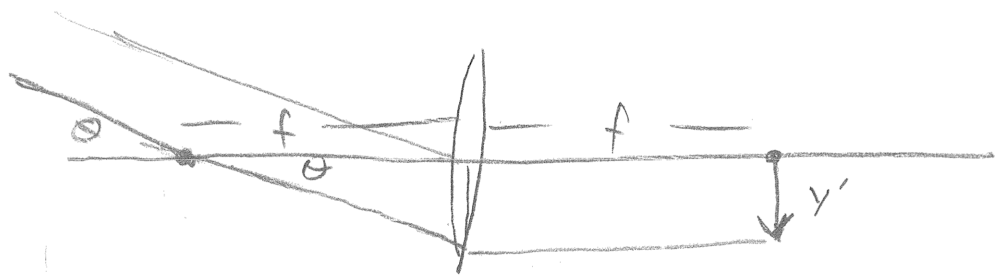




$$\tan\theta = \frac{y}{f}$$

$$\Rightarrow f = \frac{y}{\tan\theta} = \frac{2\,mm}{\tan(0.025\,rad)} \cong \frac{2\,mm}{0.025} = \boxed{8.0\,cm}$$

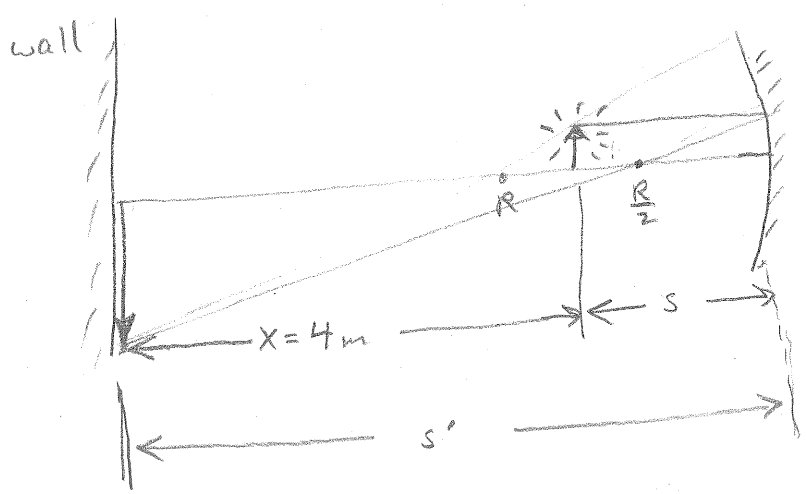
34.58 As viewed from the earth, Jupiter subtends an angle of approximately 0.014°. What is the diameter of the image of Jupiter produced by the objective of the Lick Observatory refracting telescope of focal length 18 m?



$$\tan\theta = \frac{y'}{f} \Rightarrow y' = f\tan\theta \simeq f\theta$$

$$= 18\,m\,(0.014^\circ)\frac{\pi\ rad}{180^\circ} = 0.004398\ m = \boxed{4.40\ mm}$$

34.64 A luminous object is 4.00 m from a wall. You are to use a concave mirror to project an image of the object on the wall, with the image 2.25 times the size of the object. How far should the mirror be from the wall? What should its radius of curvature be?



$$m = \frac{y'}{y} = -\frac{s'}{s} \Rightarrow s' = |m| s \;\;\&\;\; s' = x + s$$

$$\Rightarrow 0 = x + s - |m| s \Rightarrow s(|m| - 1) = x \Rightarrow s = \frac{x}{|m| - 1}$$

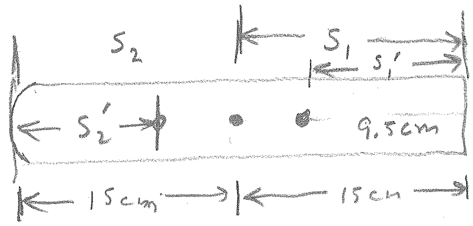
$$\Rightarrow s = \frac{4\,m}{(2.25 - 1)} = 3.2\,m \Rightarrow s' = (4\,m) + (3.2\,m)$$

$$\Rightarrow \text{mirror to wall} = s' = \boxed{7.2\,m}$$

$$\frac{2}{R} = \frac{1}{s} + \frac{1}{s'} \Rightarrow \frac{R}{2} = \frac{1}{\frac{1}{s} + \frac{1}{s'}} \Rightarrow R = \frac{2}{\frac{1}{s} + \frac{1}{s'}} =$$

$$\Rightarrow R = \frac{2}{\frac{1}{3.2m} + \frac{1}{7.2m}} = \boxed{4.43\,m}$$

34.82 A transparent rod 30.0 cm long is cut flat at one end and rounded to a hemispherical surface of radius 10.0 cm at the other end. A small object is embedded within the rod along its axis and halfway between its ends, 15.0 cm from the flat end and 15.0 cm from the vertex of the curved end. When viewed from the flat end of the rod, the apparent depth of the object is 9.50 cm from the flat end. What is its apparent depth when viewed from the curved end?



veiwing from flat end

$$\Rightarrow \underbrace{\frac{n}{s_1} + \frac{1}{s_1'} = 0}$$

$$\underbrace{\frac{n}{s_2} + \frac{1}{s_2'} = \frac{1-n}{R}}$$

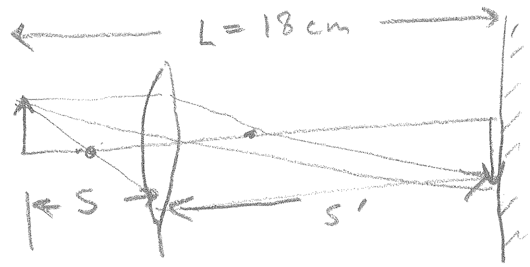
$$\Rightarrow n = -\frac{s_1}{s_1'} = \frac{15}{9.5}$$

$$s_2' = \frac{1}{\frac{1-n}{R} - \frac{n}{s_2}}$$

$$\Rightarrow s_2' = \frac{1}{\frac{1-\frac{15}{9.5}}{10\text{cm}} - \frac{\frac{15}{9.5}}{15\text{cm}}} = -21.\overline{1}\text{ cm}$$

So the apparent depth is $\boxed{21.1\text{cm}}$

34.92 An object is placed 18.0 cm from a screen. a) At what two points between object and screen may a converging lens with a 3.00-cm focal length be placed to obtain an image on the screen? b) What is the magnification of the image for each position of the lens?



$L = s + s'$ $\quad \frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$ $\quad s' = L - s$

$$\Rightarrow \frac{1}{f} = \frac{1}{s} + \frac{1}{L-s} = \frac{(L-\cancel{s}) + \cancel{s}}{s(L-s)}$$

$$\Rightarrow s(L-s) = fL \Rightarrow -s^2 + sL - fL = 0$$

$$\Rightarrow s^2 - sL + fL = 0 \Rightarrow s = \frac{L \pm \sqrt{L^2 - 4fL}}{2}$$

$$\Rightarrow s = \frac{18\text{ cm} \pm \sqrt{(18\text{ cm})^2 - 4(3\text{ cm})(18\text{ cm})}}{2}$$

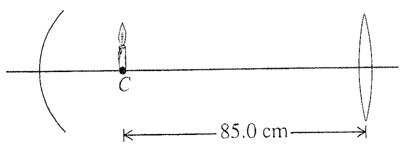
$$= 9\text{ cm} \pm 5.196\text{ cm}$$

$$\Rightarrow s = \boxed{3.80\text{ cm}, \quad 14.20\text{ cm}}$$ from the object

$$m = \frac{y'}{y} = -\frac{s'}{s} = -\frac{L-s}{s} = -\frac{18\text{ cm} - 3.8\text{ cm}}{3.8\text{ cm}}, \ -\frac{18 - 14.2}{14.2}$$

$$m = \boxed{-3.73, \ -0.268}$$

34.94 As shown in Fig. 34.54 the candle is at the center of curvature of the concave mirror, whose focal length is 10.0 cm. The converging lens has a focal length of 32.0 cm and is 85.0 cm to the right of the candle. The candle is viewed looking through the lens from the right. The lens forms two images of the candle. The first is formed by light passing directly through the lens. The second image is formed from the light that goes from the candle to the mirror, is reflected, and then passes through the lens. a) For each of these two images, draw a principal-ray diagram that locates the image. b) For each image, answer the following questions: i) Where is the image? ii) Is the image real or virtual? iii) Is the image erect or inverted with respect to the original object?



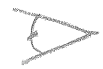
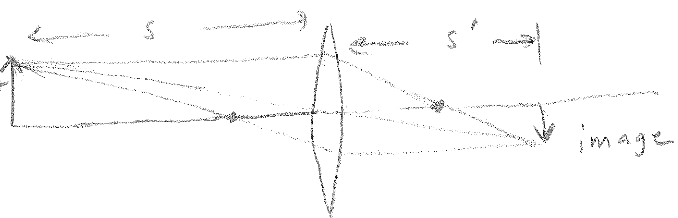


Figure 34.54 Problem 34.94.

a)

first



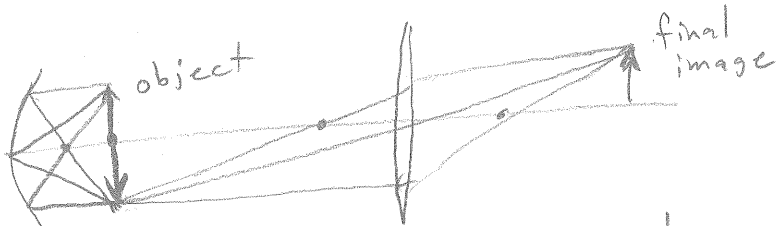
$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} \qquad s' = \frac{1}{\frac{1}{f} - \frac{1}{s}} = \frac{1}{\frac{1}{32\text{cm}} - \frac{1}{85\text{cm}}} = \boxed{51.3\text{ cm}}$$

(i) lens to image

(ii) $\boxed{\text{real}}$

(iii) $\boxed{\text{inverted}}$

second



$$\frac{2}{R} = \frac{1}{s} + \frac{1}{s'} \Rightarrow s' = \frac{1}{\frac{2}{R} - \frac{1}{s}} = \frac{1}{\frac{2}{R} - \frac{1}{R}} = \frac{1}{\frac{1}{R}} = R$$

The object distance is the same as in the first case

(i) so $s' = \boxed{51.3\text{cm}}$ as before $\boxed{\text{real}}$ $\boxed{\text{erect}}$

34.97 Rays from a lens are converging toward a point image P located to the right of the lens. What thickness t of glass with an index of refraction 1.60 must be interposed between the lens and P for the image to be formed at P', located 0.30 cm to the right of P? The locations of the piece of glass and of points P and P' are shown in Fig. 34.55.

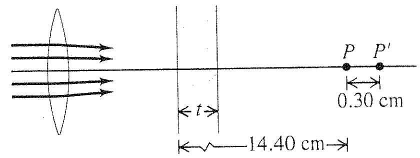
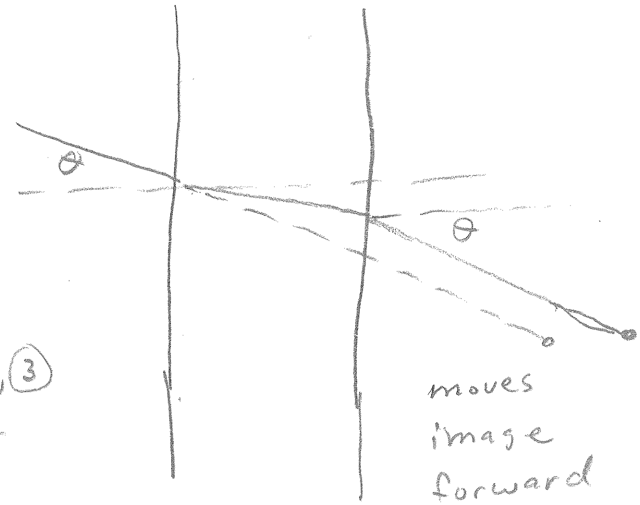
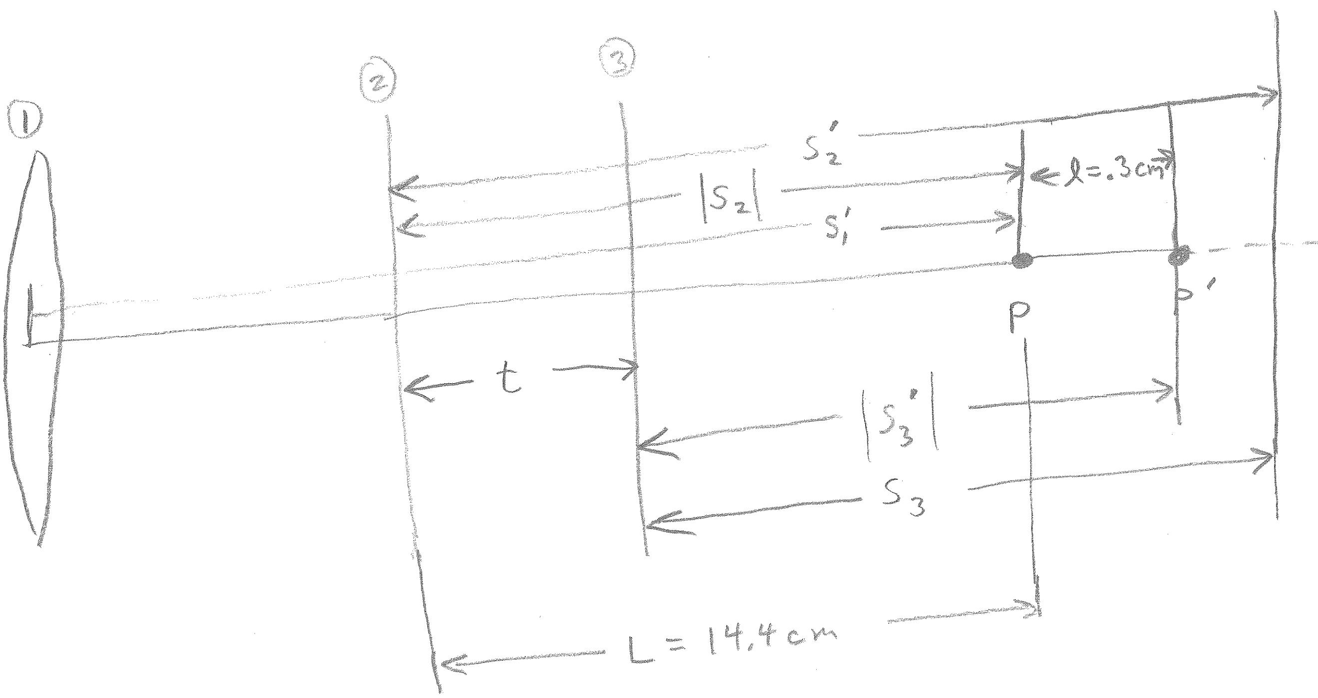


Figure 34.55 Problem 34.97.



Acts like 3 lens labeled 1, 2, 3 in the order that the images are formed

moves image forward



lens 2 $\Rightarrow -\frac{1}{|s_2|} + \frac{n}{s_2'} = 0 \Rightarrow s_2' = n|s_2| = nL$

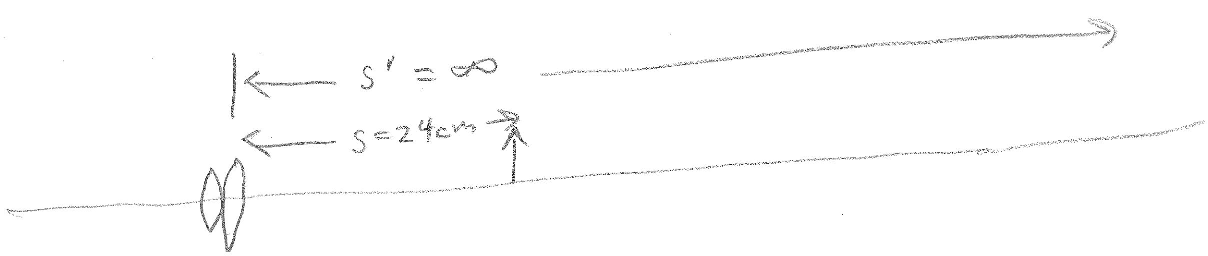
lens 3 $\Rightarrow \frac{n}{s_3} + \frac{1}{s_3'} = 0 \Rightarrow |s_3'| = \frac{1}{n}(s_3) = \frac{1}{n}((s_2') - t) = \frac{1}{n}((nL) - t)$

$|s_3'| = L - t + \ell = \frac{1}{n}(nL - t) \Rightarrow nL - nt + n\ell = nL - t$

$\Rightarrow nt - t = \cancel{nL} + n\ell - \cancel{nL} \Rightarrow t = \frac{n\ell}{(n-1)} = \frac{1.6(.3cm)}{(.6)} = \boxed{0.8 cm}$

34.109 In one form of cataract surgery the person's natural lens, which has become cloudy, is replaced by an artificial lens. The refracting properties of the replacement lens can be chosen so that the person's eye focuses on distant objects. But there is no accommodation, and glasses or contact lenses are needed for close vision. What is the power, in diopters, of the corrective contact lenses that will enable a person who has had such surgery to focus on the page of a book at a distance of 24 cm?

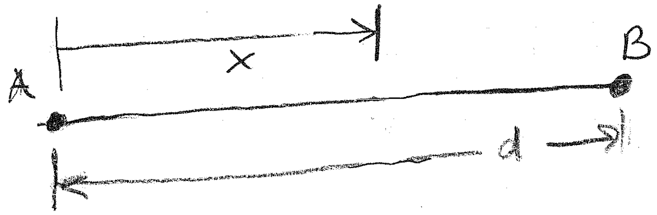
This person can only focus on object at ∞



So we put a virtual object at $s' = -\infty$

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} = \frac{1}{s} + \frac{1}{-\infty} = \frac{1}{s} + 0 = \frac{1}{.24\,m} = \boxed{+\ 4,16 \text{ diopte}}$$

35.3 Two coherent sources A and B of radio waves are 5.00 m apart. Each source emits waves with wavelength 6.00 m. Consider points along the line between the two sources. At what distances, if any, from A is the interference a) constructive; b) destructive?



path difference $\equiv D = x - (d - x)$

$\Rightarrow D = 2x - d$

a) $D = m\lambda$ for constructive interference

$\Rightarrow 2x - d = m\lambda \Rightarrow x = \dfrac{m\lambda + d}{2} = m(3m) + (2.5$

$\Rightarrow \boxed{x = 2.5m \text{ is the only constructive}}$

b) $D = (m + \tfrac{1}{2})\lambda$ for destructive interference

$\Rightarrow 2x - d = (m + \tfrac{1}{2})\lambda \Rightarrow x = d + (m + \tfrac{1}{2})\lambda$

$= \dfrac{d}{2} + \dfrac{\frac{1}{2}\lambda}{2} + \dfrac{m\lambda}{2} = \left(\dfrac{5m + 3m}{2}\right) + m\left(\dfrac{6m}{2}\right)$

$= 4m + m(3m)$

$\Rightarrow \boxed{x = 1.0m, \; 4.0m \text{ for destructive}}$

$m = -1 \qquad m = 0$