PH 221 Homework Assignment Chapter on Lenses & Optical Instruments– 26 Problems Total

1. The Sun is observed to come to a focus at a distance of $23.7\ \text{cm}$ in front of a lens.

(a) What kind of lens is this?

(b) What is the focal length of the lens?

(c) What is the power of the lens in Diopters?

Solution for Problem 1

2. A particular lens focuses an object located a distance $2.13\ \text{m}$ in front of the lens as an image found a distance $0.678\ \text{m}$ behind the lens.

(a) What type of lens is this?

(b) What is the focal length of the lens?

(c) Is the image real or virtual?

(d) Is the image upright or inverted?

Solution for Problem 2

3. A digital camera has a primary lens with a focal length of $+110.0\ \text{mm}$. The distance between the lens and the electronic sensor array is at most $135.0\ \text{mm}$.

(a) How far from the sensor array should the lens be placed to get an image of an object $13.0\ \text{m}$ away?

(b) How far from the sensor array should the lens be placed to get an image of an object $8.60\ \text{m}$ away?

(c) How far from the sensor array should the lens be placed to get an image of an object $2.76\ \text{m}$ away?

(d) What is the closest distance the object could be and still get an image?

Solution for Problem 3

4. A lens has a power $-12.00\ \mathrm{D}$ is placed a distance $14.60\ \mathrm{cm}$ from a ladybug which has a length of $4.200\ \mathrm{mm}$.

(a) Where will the image of the ladybug form relative to the lens?

(b) What type of image will be formed of the ladybug?

(c) How large will the image of the ladybug be?

Solution for Problem 4

5. You have a converging lens with a focal length of $45.0\ \mathrm{cm}$.

(a) Where would you place an object to obtain a real image that is three times larger than the object?

(b) Where would you place an object to obtain a virtual image that is three times larger than the object?

Solution for Problem 5

6. An object which is $3.24\ \text{cm}$ high is located $1.25\ \text{m}$ away from a lens.

(a) If the lens is a converging lens with a focal length of $25.0\ \text{cm}$, where is the image formed?

(b) If the lens is a converging lens with a focal length of $25.0\ \text{cm}$, what kind of image is formed?

(c) If the lens is a converging lens with a focal length of $25.0\ \text{cm}$, how tall is the image formed?

(d) If the lens is a converging lens with a focal length of $25.0\ \text{cm}$, is the image formed upright or inverted?

(e) If the lens is a diverging lens with a focal length of $25.0\ \text{cm}$, where is the image formed?

(f) If the lens is a diverging lens with a focal length of $25.0\ \text{cm}$, what kind of image is formed?

(g) If the lens is a diverging lens with a focal length of $25.0\ \text{cm}$, how tall is the image formed?

(h) If the lens is a diverging lens with a focal length of $25.0\ \text{cm}$, is the image formed upright or inverted?

Solution for Problem 6

7. An object which is $3.24\ \text{cm}$ high is located $25.0\ \text{cm}$ away from a lens.

(a) If the lens is a converging lens with a focal length of $85.0\ \text{cm}$, where is the image formed?

(b) If the lens is a converging lens with a focal length of $85.0\ \text{cm}$ what kind of image is formed?

(c) If the lens is a converging lens with a focal length of $85.0\ \text{cm}$, how tall is the image formed?

(d) If the lens is a converging lens with a focal length of $85.0\ \text{cm}$, is the image formed upright or inverted?

(e) If the lens is a diverging lens with a focal length of $85.0\ \text{cm}$ where is the image formed?

(f) If the lens is a diverging lens with a focal length of $85.0\ \text{cm}$, what kind of image is formed?

(g) If the lens is a diverging lens with a focal length of $85.0\ \text{cm}$, how tall is the image formed?

(h) If the lens is a diverging lens with a focal length of $85.0\ \text{cm}$, is the image formed upright or inverted?

Solution for Problem 7

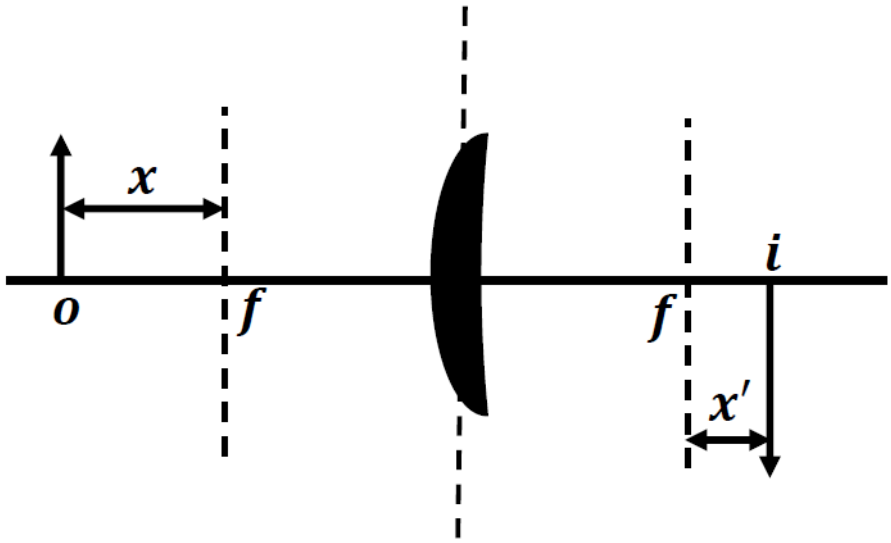
8. In an old style $35\ \text{mm}$ movie projector, the film acts as the object. The image is projected on a screen let's say located $7.50\ \text{m}$ away from a converging lens which has a focal length of $120.\ \text{mm}$. Assume a frame of film is $35.0\ \text{mm}$ in width.

(a) How far from the lens should the film be placed to create a sharp image on the screen?

(b) How wide will the film frame image be on the screen?

Solution for Problem 8

9. Newton developed a different formulation of the lens equation than we normally use. Instead of object distance (o), which is the distance between the lens plane and the object, Newton defined a distance (x), which is the distance between the object and the near focal point. Instead of image distance (i), which the distance between the lens plane and the image, Newton defined a distance (x'), which is the distance between the image and the far focal point. These distances are illustrated below.



(a) Start with the usual lens equation

$$\frac{1}{\mathrm{f}} = \frac{1}{\mathrm{o}} + \frac{1}{\mathrm{i}}$$

and derive Newton's version.

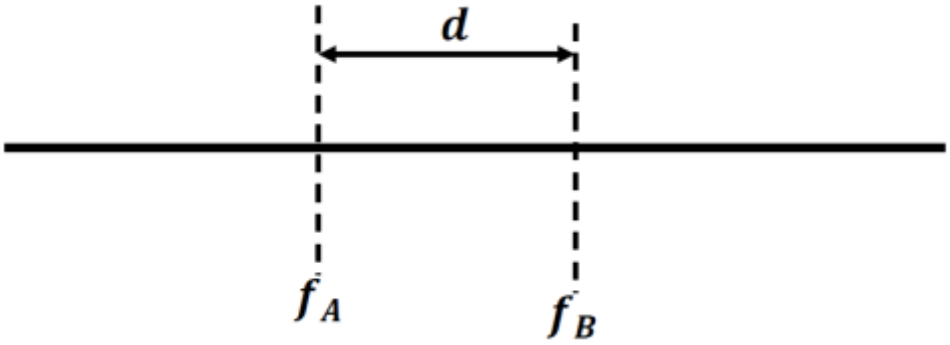
$$\mathrm{xx}' = \mathrm{f}^2$$

(b) Using the usual lens equation, find where the image is if the object is placed $56.0\ \mathrm{cm}$ away from a converging lens with a focal length of $37.0\ \mathrm{cm}$.

(c) Using Newton's form for lens equation, find where the image is if the object is placed $56.0\ \mathrm{cm}$ away from a converging lens with a focal length of $37.0\ \mathrm{cm}$.

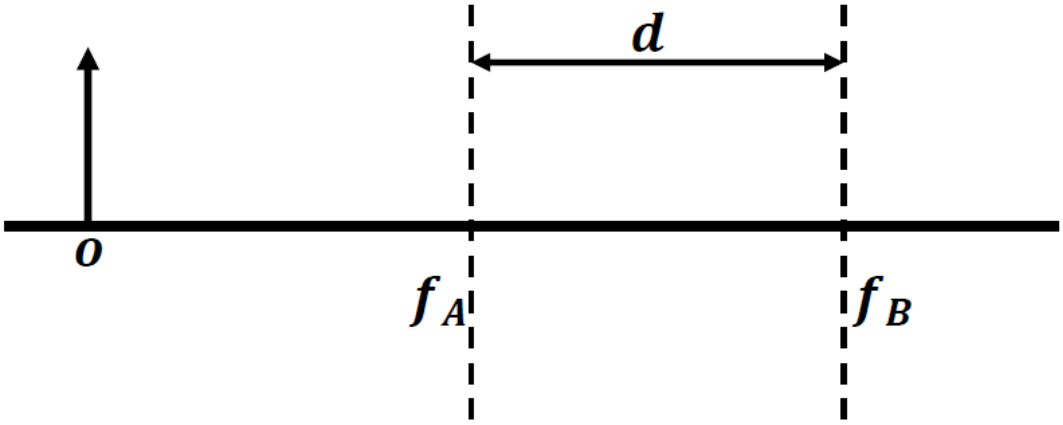
Solution for Problem 9

10. A converging lens has a focal length $(f_A = +43.0\ \text{cm})$. A diverging lens has a focal length $(f_B = -67.0\ \text{cm})$ and is located a distance of $(d = 21.0\ \text{cm})$ to the right of the converging lens. Where would an object infinitely far away and to the left of the converging lens form a final image relative to the diverging lens?



Solution for Problem 10

11. An object has a height of $4.68\ \text{cm}$ is located a distance $23.3\ \text{cm}$ on the left from a diverging lens which has a focal length $(f_A = -19.7\ \text{cm})$. A second lens is located to the right of the diverging lens a distance $34.3\ \text{cm}$. The focal length of this second lens which is a converging lens is $(f_B = +28.3\ \text{cm})$.



(a) Relative to the second lens (the converging one), where is the final image formed?

(b) Is the final image real or virtual?

(c) How tall is the final image?

(d) Is the final image upright or inverted?

Solution for Problem 11

12. A double convex lens has left surface radius of curvature $(\mathrm{R}_1 = 27.9\ \mathrm{cm})$ and the right surface radius of curvature $(\mathrm{R}_2 = 32.5\ \mathrm{cm})$. The index of refraction for the material that makes the lens is $(\mathrm{n_m} = 1.86)$. What is the focal length of this lens?

Solution for Problem 12

13. A planoconcave lens has a focal length of $-21.7\ \mathrm{cm}$ when it is made from a material with an index of refraction $(\mathrm{n_m} = 2.12)$. What is the radius of curvature for the concave surface of the lens?

Solution for Problem 13

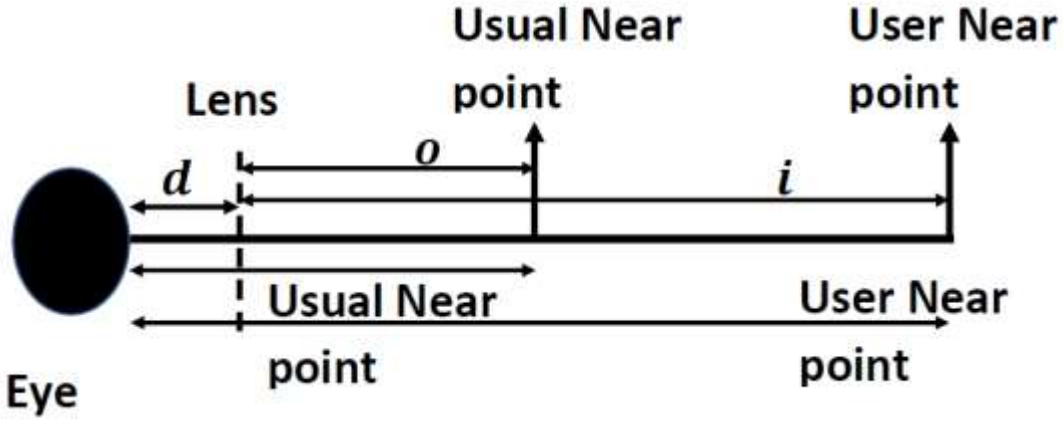
14. The largest refracting telescope ever made is the Yerkes telescope which is located in Williams Bay, Wisconsin. The telescope was built for the 1896 Chicago World's Fair and until 2018 it was operated by the University of Chicago. The diameter of the refracting lens is $1.02\ \mathrm{m}$ and it has a focal length of $19.3\ \mathrm{m}$. What is the effective "f-stop" value?

Solution for Problem 14

15. An amateur photographer is trying to take a picture of the Washington Monument which has a height of $169.\ \mathrm{m}$ tall. The photographer wants to stand a distance of $75.0\ \mathrm{m}$ from the monument. The sensor of their camera has a size of $3.50\ \mathrm{x}\ 10^{-2}\ \mathrm{m}$. What focal length lens would be required to get this picture?

Solution for Problem 15

16. As people age, their ability to read at normal distances becomes more difficult. Consider someone who needs a book held at a distance of $63.0\ \mathrm{cm}$ from their eye. What should the power of a lens which will sit a distance of $2.00\ \mathrm{cm}$ from their eye and will allow them to see a book at the usual near point of $25.0\ \mathrm{cm}$?



Solution for Problem 16

17. For a particular person a lens with a power of $+3.58\ \mathrm{D}$ placed $2.00\ \mathrm{cm}$ in front of their eye.

(a) Is this eye near or far sighted?

(b) What is the eye's near point without the corrective lens?

Solution for Problem 17

18. A person has an uncorrected vision far point of $23.0\ \mathrm{m}$. What should the focal length be for a contact lens to correct their far point to be infinity?

Solution for Problem 18

19. What is the focal length of a lens used with a relaxed eye to produce a magnification of $12.5\ \mathrm{X}$?

Solution for Problem 19

20. A rfid chip is circular and has a diameter of $5.00\ \mathrm{mm}$. You place it a distance of $7.75\ \mathrm{cm}$ from a converging lens with a focal length of $8.00\ \mathrm{cm}$.

(a) Where does the image form?

(b) Is the image real or virtual?

(c) What is the size of the image?

(d) What is the angular magnification of the lens assuming not a relaxed eye condition?

Solution for Problem 20

21. A particular magnifying glass is rated at $5.00\ \mathrm{X}$ for a normal eye that is relaxed.

(a) What would be the magnification rating for a relaxed eye whose near point is $78.0\ \mathrm{cm}$?

(b) What would be the magnification rating for a relaxed eye whose near point is $18.0\ \mathrm{cm}$?

(c) Explain the differences between the three eyes.

Solution for Problem 21

22. For an astronomical telescope the objective lens has a focal length of $93.4\ \text{cm}$.

(a) What focal length lens should be used as an eye piece if the overall angular magnification is to be $45.0\ \text{X}$?

(b) What is the length of the telescope if it is adjusted for minimum eye strain (relaxed eye) ?

Solution for Problem 22

23. A telescope for astronomy has an objective lens $(f_o = 67.0\ \text{cm})$ located a distance of $71.0\ \text{cm}$ from the eye piece. Assuming the minimum eye strain condition what is the angular magnification of this telescope?

Solution for Problem 23

24. The Moon's image appears to be magnified by a factor $95.0\ \text{X}$ by a reflecting astronomical telescope. The eye piece has a focal length of $6.80\ \text{cm}$.

(a) What is the focal length of objective mirror?

(b) What is the radius of curvature of the objective mirror?

Solution for Problem 24

25. What is the focal length of an eye piece for a microscope with a magnification of $720.\ \text{x}$. The focal length of the objective lens is $0.450\ \text{cm}$, and the barrel length is $18.25\ \text{cm}$. Assume a normal eye (i.e. Near point is $25.0\ \text{cm}$) and the final image is at infinity.

Solution for Problem 25

26. An eye piece has an angular magnification of $11.0\ \mathrm{X}$ and it is paired with an objective lens with an angular magnification of $63.0\ \mathrm{X}$. The two lenses are placed a distance $25.0\ \mathrm{cm}$ apart to make a simple microscope.

(a) Determine the total magnification of the microscope.

(b) Find the focal length of the eye piece.

(c) Determine the focal length of the objective lens.

(d) Where should the object be placed relative to the objective lens to create an image at infinity so a relaxed eye can view it?

Solution for Problem 26

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