EXERCISES 2.A

1. a) With the aid of a ray diagram, describe how a convex lens is used as a magnifying glass.
   b) Explain why an image formed in a magnifying glass is almost free from chromatic aberration.
2. a) When is a compound microscope said to be in normal use?
   b) Derive an expression for the magnifying power of a compound microscope in normal use.
   c) Explain why the lenses that make up a compound microscope are of short focal lengths.
3. a) When is a telescope said to be in normal adjustment.
   b) What is meant by the eye ring as applied to optical instruments.
   c) What are the differences between microscope and telescopes?

4.a) Explain why prisms are preferred to mirrors in prism binoculars.
   b) State the advantages of reflecting telescopes over refracting telescopes.
   c) The objective of an astronomical telescope in a normal adjustment has a diameter of 15cm and a focal length of 400cm. The eye piece has a focal length of 2.5cm. Find the magnifying power of the telescope.
5. a) A distant objective subtending an angle of $3x10^{-5}$ and in viewed with a reflecting telescope whose objective is a concave mirror of focal length 10m. The reflected light falls on a concave mirror placed 9.5cm from the pole of the objective which
reflects the length back and a real image is formed at the pole of the objective where there is a hole. The image is viewed with a convex lens of focal length 5cm used as a magnifying glass which produces the final image at infinity.
6. How far must a 50mm focal-length camera lens be moved from its infinity setting to sharply focus an object 3m away?
7. Sue is far-sighted with a near point of 100cm. Reading glasses must have what lens power so that she can read a newspaper at a distance of 25cm? Assume the lens is very close to the eye.
8. A near-sighted eye has near and far point of 12cm and 17cm, respectively.
a) What lens power is needed for this person to see distant objects clearly,
b) What then will be the near point? Assume that the lens is 2cm from the eye (typical for eye glasses).
9. What power contact lens is needed for an eye to see distant objects if its point is 25cm?
10. An 8cm focal-length converging lens is used as a "jeweler's loupe", which is a magnifying glass. Estimate:
a) the magnification when the eye is relaxed,
b) the magnification if the eye is focused at its near point N=25cm.
11. A compound microscope consists of a 10X eyepiece and 50X objective 17cm apart. Determine:
a) the overall magnification,
b) the focal length of each lens,
c) the position of the object when the final image is in focus with eye relaxed. Assume a normal eye, so N = 25cm.
12. A near-sighted person cannot see objects clearly beyond 25.0cm (her far point). If she has no astigmatism and contact lenses are prescribed for her, what power and type of lens are required to correct her vision?
13. Microscope uses an eyepiece with a focal length of 1.4cm. Using a normal eye with a final image at infinity the tube length is 17.5cm and the focal length of the objective lens is 0.65cm. What is the magnification of the microscope?

EXERCISES 2.B

Section : Images Formed by Refraction

1.A cubical block of ice 50cm on a side is placed on a level floor over a speck of dust. Find the location of the image of the speck as viewed from above. The index of refraction of ice is 1.309.
2.A glass sphere (n =1.5) with a radius of 15cm has a tiny air bubble 5cm above its center. The sphere is viewed looking down along the extended radius containing the bubble. What is the apparent depth of the bubble below the surface of the sphere?
3**.** A simple model of the human eye ignores its lens entirely. Most of what the eye does to light happens at the outer surface of the transparent cornea. Assume that this surface has a radius of curvature of 6mm, and assume that the eyeball contains just one fluid with a refractive index of 1.4. Prove that a very distant object will be imaged on the retina, 21mm behind the cornea. Describe the image.
4. One end of a long glass rod (n =1.5) is formed into a convex surface with a radius of curvature of 6cm. An object is located in air along the axis of the rod. Find the image positions corresponding to object distances of :
a) 20cm b) 10cm c) 3cm from the end of the rod.
5. A transparent sphere of unknown composition is observed to form an image of the Sun on the surface of the sphere opposite the Sun. What is the refractive index of the sphere material?

Section : Thin Lenses

6. A contact lens is made of plastic with an index of refraction of 1.5. The lens has an outer radius of curvature of +2cm and an inner radius of curvature of +2.5cm. What is the focal length of the lens?

7.The left face of a biconvex lens has a radius of curvature of magnitude 12cm, and the right face has a radius of curvature of magnitude 18cm. The index of refraction of the glass is 1.44.

a) Calculate the focal length of the lens.

b) What If? Calculate the focal length the lens has after is turned around to interchange the radii of curvature of the two faces.

8. A converging lens has a focal length of 20cm. Locate the image for object distances of :

a) 40cm, b) 20cm

c) 10cm. For each case, state whether the image is real or virtual and upright or inverted. Find the magnification in each case.

9. A thin lens has a focal length of 25cm. Locate and describe the image when the object is placed :

a) 26.0 cm b) 24.0 cm in front of the lens.

10. An object located 32cm in front of a lens forms an image on a screen 8cm behind the lens.

a) Find the focal length of the lens.

b) Determine the magnification.

c) Is the lens converging or diverging?

11. A person looks at a gem with a jeweler's loupe a converging lens that has a focal length of 12.5cm. The loupe forms a virtual image 30cm from the lens.

a) Determine the magnification. Is the image upright or inverted?

b) Construct a ray diagram for this arrangement.

12. The projection lens in a certain slide projector is a single thin lens. A slide 24mm high is to be projected so that its image fills a screen 1.8m high. The slide-to-screen distance is 3m.

a) Determine the focal length of the projection lens.

b) How far from the slide should the lens of the projector be placed in order to form the image on the screen?

13.An object is located 20cm to the left of a diverging lens having a focal length f =-32cm. Determine:

a) the location b) the magnification of the image.

c) Construct a ray diagram for this arrangement.

14. In some types of optical spectroscopy, such as photoluminescence and Raman spectroscopy, a laser beam exits from a pupil and is focused on a sample to stimulate electromagnetic radiation from the sample. The focusing lens usually has an antireflective coating preventing any light loss. Assume a 100mW laser is located 4.8m from the lens, which has a focal length of 7cm.

a) How far from the lens should the sample be located so that an image of the laser exit pupil is formed on the surface of the sample?

b) If the diameter of the laser exit pupil is 5mm, what is the diameter of the light spot on the sample?

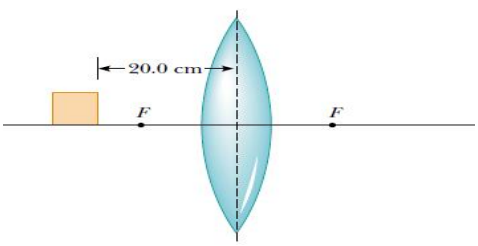
c) What is the light intensity at the spot?

15. Figure shows a thin glass (n=1.5) converging lens for which the radii of curvature are R_1=15cm and R_2=-12cm. To the left of the lens is a cube having a face area of 100 cm^2. The base of the cube is on the axis of the lens, and the right face is 20cm to the left of the lens.

a) Determine the focal length of the lens.

b) Draw the image of the square face formed by the lens. What type of geometric figure is this?

c) Determine the area of the image.



16. An object is at a distance d to the left of a flat screen. A converging lens with focal length $f < d/4$ is placed between object and screen.

a) Show that two lens positions exist that form an image on the screen, and determine how far these positions are from the object.

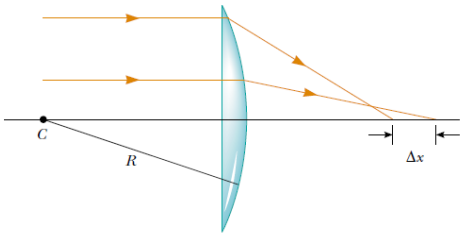
b) How do the two images differ from each other?

17. The South American capybara is the largest rodent on Earth; its body can be 1.2m long. The smallest rodent is the pygmy mouse found in Texas, with an average body length of 3.6cm. Assume that a pygmy mouse is observed by looking

through a lens placed 20cm from the mouse. The whole image of the mouse is the size of a capybara. Then the lens is moved a certain distance along its axis, and the image of the mouse is the same size as before! How far was the lens moved?

Section : Lens Aberrations

18. The magnitudes of the radii of curvature are 32.5cm and 42.5cm for the two faces of a biconcave lens. The glass has index of refraction 1.53 for violet light and 1.51 for red light. For a very distant object, locate and describe:
a) the image formed by violet light,
b) the image formed by red light.
19. Two rays traveling parallel to the principal axis strike a large plano-convex lens having a refractive index of 1.6. If the convex face is spherical, a ray near the edge does not pass through the focal point (spherical aberration occurs). Assume this face has a radius of curvature of 20cm and the two rays are at distances h_1= 0.5cm and h_2=12cm from the principal axis. Find the difference -x in the positions where each crosses the principal axis.



Section : The Eye

20.A nearsighted person cannot see objects clearly beyond 25cm (her far point). If she has no astigmatism and contact lenses are prescribed for her, what power and type of lens are required to correct her vision?
21. The accommodation limits for Nearsighted Nick's eyes are 18cm and 80cm. When he wears his glasses, he can see faraway objects clearly. At what minimum distance is he able to see objects clearly?
22. A person sees clearly when he wears eyeglasses that have a power of -4 diopters and sit 2cm in front of his eyes. If the person wants to switch to contact lenses, which are placed directly on the eyes, what lens power should be prescribed?

Section : The Simple Magnifier ,The Compound Microscope and The Telescope

23. A lens that has a focal length of 5cm is used as a magnifying glass.
a) To obtain maximum magnification, where should the object be placed?
b) What is the magnification?
24. The distance between eyepiece and objective lens in a certain compound microscope is 23cm. The focal length of the eyepiece is 2.5cm, and that of the objective is 0.4cm. What is the overall magnification of the microscope?
25. The desired overall magnification of a compound microscope is 140x. The objective alone produces a lateral magnification of 12x. Determine the required focal length of the eyepiece.
26.The Yerkes refracting telescope has a 1m diameter objective lens of focal length 20m. Assume it is used with an eyepiece of focal length 2.5cm.
a) Determine the magnification of the planet Mars as seen through this telescope.
b) Are the Martian polar caps right side up or upside down?
27. Astronomers often take photographs with the objective lens or mirror of a telescope alone, without an eyepiece.
a) Show that the image size h' for this telescope is given by $h' = f\,h/(f - p)$ where h is the object size, f is the objective focal length, and p is the object distance.
b) What If? Simplify the expression in part (a) for the case in which the object distance is much greater than objective focal length.
c) The "wingspan" of the International Space Station is 108.6m, the overall width of its solar panel configuration. Find the width of the image formed by a telescope objective of focal length 4m when the station is orbiting at an altitude of 407km.
28. Galileo devised a simple terrestrial telescope that produces an upright image. It consists of a converging objective lens and a diverging eyepiece at opposite ends of the telescope tube. For distant objects, the tube length is equal to the objective focal length minus the absolute value of the eyepiece focal length.
a) Does the user of the telescope see a real or virtual image?
b) Where is the final image?
c) If a telescope is to be constructed with a tube of length 10cm and a magnification of 3, what are the focal lengths of the objective and eyepiece?