Physics Standard X: Lenses Chapter Answers

Comprehensive Solutions to All Questions and Activities

1 Answers to Questions and Activities

1.1 Introductory Questions

1. **How does a telescope make distant objects appear so distinct and close?**
   Answer: A refracting telescope uses a convex objective lens with a long focal length to form a small, real, inverted image of a distant object at its focus. The convex eyepiece, with a shorter focal length, magnifies this image, forming a virtual, magnified image that appears closer and clearer to the observer.

2. **Where else are lenses used? Write them down.**
   Answer:
   - Toys
   - Spectacles
   - Door lens (for viewing outside)
   - Cameras
   - Microscopes
   - Telescopes

3. **What makes these lenses different from a sheet of glass?**
   Answer: Lenses have curved surfaces (parts of spheres) that refract light to converge or diverge it, forming images or magnifying objects. A glass sheet, with flat surfaces, does not significantly bend light, maintaining the size of the illuminated area.

4. **Allow sunlight to fall on a paper through a thin sheet of glass. What is observed?**
   Answer: The illuminated area on the paper remains the same size regardless of the distance between the glass and the paper, with no significant change in light intensity.

5. **Vary the distance between the paper and the glass sheet. What do you observe?**
   Answer: The size of the illuminated area does not change, as the glass sheet does not focus light.

6. **Do the same activity using a reading lens. What is your observation?**
   Answer: At a specific distance, the illuminated area shrinks significantly, and the light intensity increases, forming a bright spot. Holding the lens longer at this point can cause the paper to smolder and catch fire.

7. **What feature does the lens have that the glass sheet doesn't?**
   Answer: The lens has curved surfaces that converge light to a focal point, increasing intensity, unlike the flat glass sheet.

8. **Observe the lens used in the previous activity and note down its characteristics.**
   Answer:

- Thicker in the middle
- Magnifies objects
- Converges light rays

9. **Observe another type of lens (concave lens). What are its features?**
Answer:
   - Thinner in the middle
   - Diverges light rays
   - Forms diminished images

10. **Try to burn a piece of paper with such lenses (concave). Is it possible?**
Answer: No, a concave lens diverges light, preventing it from focusing to a point intense enough to burn paper.

11. **List the characteristics of concave lenses and convex lenses in the table.**
Answer:

Table 1: Characteristics of Lenses

Convex Lens	**Concave Lens**
Thicker in middle	Thinner in middle
Converges light	Diverges light
Real or virtual images	Virtual images only
Magnified or diminished	Always diminished
Can burn paper	Cannot burn paper

12. **Observe the letters through each lens and move the lens to one side. What is the observation?**
Answer:
   - Convex lens: Letters appear to move in the opposite direction.
   - Concave lens: Letters appear to move in the same direction.

13. **Refracting surfaces of a lens are parts of (spheres / circles)?**
Answer: Spheres. Each refracting surface is part of a sphere, causing light refraction.

14. **Which figure represents convex lens? And which one represents concave lens?**
Answer:
   - Convex lens: Figure 2.6 (a) (thicker in the middle).
   - Concave lens: Figure 2.6 (b) (thinner in the middle).

15. **What do C_1 and C_2 indicate?**
Answer: C_1 and C_2 are the centres of curvature of the two spherical refracting surfaces of the lens.

16. **Which refers to the optic centre? (C_1, O, C_2)**
Answer: O. The optic centre is the midpoint of the lens.

17. **Which represents the optic axis?**
Answer: The imaginary line passing through the optic centre and centres of curvature (C_1, C_2).

18. **What do you observe? (Smoke box experiment with convex lens)**
Answer: Parallel laser rays converge to a point (principal focus) on the opposite side of the convex lens, visible in the smoke.

19. **Depict the path of light (convex lens in smoke box).**
Answer: Parallel rays enter the convex lens, bend inward, and converge at the principal focus on the opposite side.

20. **Repeat the experiment shown by passing the light through the opposite hole. Didn't the light rays converge in this case too?**
Answer: Yes, light rays converge at the principal focus on the opposite side, as convex lenses have two equidistant foci.

21. **Do refracted rays pass through the principal focus of a concave lens?**
Answer: No, refracted rays diverge and appear to originate from the principal focus on the same side.

22. **Is the principal focus of a concave lens considered virtual or real?**
Answer: Virtual. Rays do not actually pass through the focus but appear to diverge from it.

23. **Try to form an image using a concave lens. Is it possible? Write down the results of the observation in the science diary.**
Answer: A concave lens cannot form a real image on a screen, as it diverges light. The image is virtual, erect, and diminished, visible only by looking through the lens, located between the focus and optic centre.

24. **Which lens was used to form an image on the screen?**
Answer: Convex lens. It forms real images that can be projected on a screen.

25. **Write down examples for real images.**
Answer:
    - Image captured on a camera.
    - Image formed on a cinema screen.
    - Image projected by a projector.

26. **Record the positions and properties of the image in the table by placing the object at various positions.**
Answer:

27. **Write down in table the details of the path of light rays passing through the convex lens through different paths from point A.**
Answer:

28. **Complete the ray diagram of the formation of image when the object is placed at different positions. Find the position and characteristics of the images.**
Answer:

Table 2: Image Formation by Convex Lens

Position of Object	Position of Image	Characteristics of Image
Beyond 2F	Between F and 2F	Diminished, inverted, real
At 2F	At 2F	Same size, inverted, real
Between F and 2F	Beyond 2F	Magnified, inverted, real
At F	At infinity	Highly magnified, inverted, real
Between F and O	Same side	Magnified, erect, virtual

Table 3: Light Ray Paths through Convex Lens

Ray Path	Behavior
Parallel to optic axis	Passes through principal focus on other side
Through optic centre	Passes undeviated
Through focus (same side)	Becomes parallel after refraction

- **Beyond 2F**: Image between F and 2F, inverted, diminished, real.
- **At 2F**: Image at 2F, inverted, same size, real.
- **Between F and 2F**: Image beyond 2F, inverted, magnified, real.
- **At F**: Image at infinity, inverted, highly magnified, real.
- **Between F and O**: Image on same side, erect, magnified, virtual.

29. **Do refracted rays converge? (Object at F)**
Answer: No, refracted rays become parallel, forming an image at infinity.

30. **What would be the characteristics of the image? (Object at F)**
Answer: Inverted, highly magnified, real.

31. **Does a convex lens always form only real images?**
Answer: No, a convex lens forms virtual images when the object is between the focus and optic centre, as in a magnifying glass.

32. **Complete table by observing the change in the path of light as it passes through a concave lens.**
Answer:

Table 4: Light Ray Paths through Concave Lens

Ray Path	Behavior
Parallel to optic axis	Diverges, appears from principal focus (same side)
Through optic centre	Passes undeviated
Directed toward focus (opposite side)	Becomes parallel after refraction

33. **Object between F and 2F (Concave lens): Position and characteristics of the image.**
Answer:

- Position: Between F and optic centre, same side.
- Characteristics: Virtual, erect, diminished.

34. **Object between F and lens (Concave lens): Draw the ray diagram and note position and characteristics.**
Answer: The ray diagram shows rays diverging after passing through the concave lens, appearing to come from a point between F and O.

- Position: Between F and optic centre, same side.
- Characteristics: Virtual, erect, diminished.

35. **Complete the given table based on the image formation by a concave lens.**
Answer:

Table 5: Image Formation by Concave Lens

Position of Object	Position of Image	Real/Virtual	Inverted/Erect	Magnified/Dimi
Between F and 2F	Between F and O	Virtual	Erect	Diminished
Between F and Lens	Between F and O	Virtual	Erect	Diminished

36. **What could be the reason for the image formed by a concave lens always being virtual?**
Answer: Concave lenses diverge light rays, preventing them from converging to form a real image. The rays appear to originate from a virtual focus on the same side, resulting in a virtual image.

37. **Which letter indicates the distance to the object (OB) in the figure?**
Answer: u. It represents the object distance from the optic centre.

38. **Which distance does the letter v represent in the figure?**
Answer: v represents the image distance from the optic centre.

39. **Which distance does the letter f stand for?**
Answer: f represents the focal length, the distance from the optic centre to the principal focus.

40. **Observe the distance to the object and the distance to the image depicted in the figure. Write down the measurements using the sign conventions and calculate the focal length of the lens.**
Answer: Given: $u = -90\,\text{cm}$, $v = +30\,\text{cm}$.
Using lens equation: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{30} - \frac{1}{-90} = \frac{1}{30} + \frac{1}{90} = \frac{4}{90}$.
Thus, $f = \frac{90}{4} = 22.5\,\text{cm}$.

41. **Complete table based on Cartesian sign convention.**
Answer:

42. **Calculate the magnification using the measurements in the figure and write down the characteristics.**
Answer: Given: $u = -90\,\text{cm}$, $v = +30\,\text{cm}$, $h_o = +1.8\,\text{cm}$, $h_i = -0.6\,\text{cm}$.
Magnification: $m = \frac{h_i}{h_o} = \frac{-0.6}{1.8} = -\frac{1}{3}$, or $m = \frac{v}{u} = \frac{30}{-90} = -\frac{1}{3}$.
Characteristics: Image is real, inverted, diminished ($|m| < 1$).

Table 6: Cartesian Sign Convention

Measurements	Fig. 2.22 (a)		Fig. 2.22 (b
	Sign	Reason	Sign
u	Negative (-25 cm)	Opposite to incident ray	Negative (-25 cm)
v	Positive	Same direction as incident ray	Negative
f	Positive	Convex lens, real focus	Negative
h_o	Positive	Above optic axis	Positive
h_i	Negative	Inverted, below optic axis	Positive

43. **Complete table by considering the relation of magnification with the nature of the image.**
Answer:

Table 7: Magnification and Image Nature

Nature of Image	Sign of Magnification
Erect	Positive
Inverted	Negative
Real	Negative
Virtual	Positive

44. **What does +2.00 refer to?**
Answer: It refers to the power of a convex lens in spectacles, $P = +2.00\,\text{D}$, indicating a focal length of $f = \frac{1}{2} = 0.5\,\text{m} = 50\,\text{cm}$, used for hyperopia correction.

45. **What is the power of a concave lens of focal length 25 cm?**
Answer: Focal length $f = -25\,\text{cm} = -0.25\,\text{m}$.
Power: $P = \frac{1}{f} = \frac{1}{-0.25} = -4\,\text{D}$.

46. **If it is a convex lens, what will be the sign of the power?**
Answer: Positive. Convex lenses have a real focus, giving positive power.

47. **What type of lens is in the doctor's prescription (Fig. 2.24)?**
Answer: Convex lens, as indicated by the positive power (+2.00 D).

48. **What is the use of a compound microscope?**
Answer: It magnifies small objects (e.g., cells) for detailed observation in scientific studies.

49. **Observe figure and complete table identifying the characteristics of lenses used in compound microscope.**
Answer:

Table 8: Compound Microscope Lenses

Lens	Type	Focal Length	Image Characteristics
Objective	Convex	Shorter	Real, inverted, magnified
Eyepiece	Convex	Longer	Virtual, erect, magnified

50. **Where should the object to be observed be kept with reference to the objective?**
Answer: Between F_o and $2F_o$.

51. **What is the position of the image formed by the objective?**
Answer: Beyond $2F_o$, on the opposite side.

52. **What are the characteristics of this image?**
Answer: Real, inverted, magnified.

53. **What would be the characteristics of the image formed by the eyepiece?**
Answer: Virtual, erect, magnified.

54. **Increasing the focal length of the objective lens will not be beneficial in the compound microscope. What is the reason?**
Answer: A longer focal length reduces the magnification of the objective's image, making the final image smaller, which is undesirable for observing microscopic details.

55. **Observe figures and complete the table given below (telescope lenses).**
Answer:

Table 9: Telescope Lenses

Lens	Focal Length	Aperture	Image Characteristics
Objective	Longer	Larger	Small, real, inverted
Eyepiece	Shorter	Smaller	Virtual, magnified

56. **Where is the position of the object? (Telescope)**
Answer: Far away (effectively at infinity).

57. **Focal length of the objective is (lesser / greater)?**
Answer: Greater.

58. **What are the characteristics of the image formed by the objective?**
Answer: Small, real, inverted.

59. **Which of the lenses use this image as its object?**
Answer: Eyepiece.

60. **Through which lens is the image viewed?**
Answer: Eyepiece.

61. **The image we see through the eyepiece is (real / virtual)?**
Answer: Virtual.

62. **Why is it said not to look at the sun through a telescope?**
Answer: Focused sunlight can burn the retina, causing permanent eye damage.

2 Assessment Questions

1. **The focal length of a convex lens is 20 cm. An object of height 3irono 3 cm is located at a distance of 60 cm from its optic centre on the optic axis.**

a) **Calculate the height of the image.**
Answer: Using lens equation: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, $f = 20\,\text{cm}$, $u = -60\,\text{cm}$.
$\frac{1}{20} = \frac{1}{v} - \frac{1}{-60}$, $\frac{1}{v} = \frac{1}{20} - \frac{1}{60} = \frac{2}{60}$, $v = 30\,\text{cm}$.
Magnification: $m = \frac{v}{u} = \frac{30}{-60} = -0.5$.
Image height: $h_i = m \cdot h_o = -0.5 \cdot 3 = -1.5\,\text{cm}$.
Explanation: The negative magnification indicates an inverted image, with height reduced to 1.5 cm.

b) **What are the characteristics of the image obtained?**
Answer: Real, inverted, diminished.
Explanation: Object beyond 2F forms a real, inverted, smaller image between F and 2F.

c) **The focal length of a lens is 20 cm.**

a) **An object is placed 30 cm away from the lens. Calculate how far the screen should be placed to get a clear image.**
Answer: Assuming convex lens, $f = 20\,\text{cm}$, $u = -30\,\text{cm}$.
$\frac{1}{20} = \frac{1}{v} - \frac{1}{-30}$, $\frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}$, $v = 60\,\text{cm}$.
Screen should be 60 cm from the lens.
Explanation: The image distance v is positive, indicating a real image.

b) **If the height of the object is 1.2 cm, what will be the height of the image appearing on the screen?**
Answer: Magnification: $m = \frac{v}{u} = \frac{60}{-30} = -2$.
Image height: $h_i = m \cdot h_o = -2 \cdot 1.2 = -2.4\,\text{cm}$.
Explanation: The negative sign indicates an inverted image, magnified to 2.4 cm.

c) **The focal length of a convex lens is 100 mm. An object of height 15 mm is located 60 mm from the optic centre on its optic axis.**

a) **Draw its ray diagram on a graph paper and find the position and height of the image.**
Answer: $f = 100\,\text{mm}$, $u = -60\,\text{mm}$, $h_o = 15\,\text{mm}$.
$\frac{1}{100} = \frac{1}{v} - \frac{1}{-60}$, $\frac{1}{v} = \frac{1}{100} - \frac{1}{60} = -\frac{1}{150}$, $v = -150\,\text{mm}$.
Magnification: $m = \frac{v}{u} = \frac{-150}{-60} = 2.5$.
Image height: $h_i = 2.5 \cdot 15 = 37.5\,\text{mm}$.
Ray diagram: Rays diverge, forming a virtual, erect image 150 mm on the same side.
Explanation: Object between F and O forms a magnified virtual image.

b) **Calculate the magnification if the distance to the object is 20 mm.**
Answer: $u = -20\,\text{mm}$, $f = 100\,\text{mm}$.
$\frac{1}{100} = \frac{1}{v} - \frac{1}{-20}$, $\frac{1}{v} = \frac{1}{100} - \frac{1}{20} = -\frac{4}{100}$, $v = -25\,\text{mm}$.
Magnification: $m = \frac{v}{u} = \frac{-25}{-20} = 1.25$.
Explanation: The image is virtual, erect, and slightly magnified.

c) **Four statements are given regarding the image formed by a concave lens. Choose the correct answer.**

d) It will be diminished and inverted

e) It will be diminished and virtual

f) It will be magnified and virtual

g) It will be diminished and erect

Answer: c) Second and fourth statements are true
Explanation: Concave lenses always form virtual, erect, diminished images.

h) **A concave lens has a focal length of 50 cm. What will be its power?**

i) +2 D

j) +0.5 D

k) -2 D

l) -0.5 D

Answer: c) -2 D
Explanation: $f = -50\,\text{cm} = -0.5\,\text{m}$, $P = \frac{1}{-0.5} = -2\,\text{D}$.

m) **Find the most appropriate statement related to a telescope.**

n) Objective has shorter focal length, eyepiece has longer

o) Objective has longer focal length, eyepiece has shorter

p) Both are concave lenses

q) Objective is concave, eyepiece is convex

Answer: b) Objective has longer focal length, eyepiece has shorter
Explanation: The objective's long focal length forms a small image, magnified by the eyepiece.

r) **When an object is placed in front of a lens, the image formed is inverted.**

s) **Is it real or virtual?**
Answer: Real
Explanation: Inverted images from convex lenses are real, formed on the opposite side.

t) **What will you do if you want another image of this obtained image to be real, erect, and of the same size?**
Answer: Place a convex lens with the same focal length at 2F from

the first image.
Explanation: At 2F, a convex lens forms a real, erect (relative to the first image), same-sized image.

u) **When an object is placed at the principal focus of a lens, an image that is erect and diminished is obtained.**

v) **What kind of lens is this?**
Answer: Concave lens
Explanation: Only concave lenses form erect, diminished images regardless of object position.

w) **Draw the ray diagram of the image formation.**
Answer: Draw parallel ray diverging, appearing from the virtual focus; ray through optic centre passes straight; image forms between F and O, erect, diminished.

x) **The image (IM) obtained when an object is placed in front of a lens is depicted.**

y) **If PQ is a lens in the figure, what type of lens does PQ represent?**
Answer: Convex lens
Explanation: Assuming an inverted image, it indicates a real image from a convex lens.

z) **Complete the ray diagram and find the position of the object.**
Answer: For an inverted image, the object is beyond F. Draw rays: parallel ray to focus, optic centre ray straight, converging at the image. Object is likely beyond 2F for a diminished image.

) **The height of the object is than the height of the image (greater / lesser).**
Answer: Greater
Explanation: Inverted, diminished images have smaller height than the object.

) **Match the items in the columns A, B, and C appropriately.**
Answer:

Table 10: Matching Table

A	B	C
Magnification	$\frac{h_i}{h_o}$	$\frac{v}{u}$
Power of lens	$\frac{1}{f}$	Dioptre
Real image	Inverted image	h_i negative
Erect image	Erect image	h_i positive

3 Extended Activities

) **Collect, tabulate, and analyse information regarding the type of lens used in different types of spectacles, the power of lens, age of users, and the problems faced by them.**
Answer:

- **Method**: Survey users, noting age, vision issue, lens type (convex/concave), and power (e.g., +2 D, -3 D).
- **Table Example**:

Table 11: Spectacles Data

Age	Vision Issue	Lens Type	Power (D)
50	Hyperopia	Convex	+2.0
20	Myopia	Concave	-3.0

- **Analysis**: Older users often use convex lenses for hyperopia; younger users use concave for myopia. Issues include lens weight and adjustment time.

) **Collect a transparent polythene bag. Fill it with water and tie to get it almost in the shape of a sphere. Use it as a convex lens to form various sized images of a burning candle.**
Answer: Fill a polythene bag with water, tie it to form a spherical shape, and hold it between a candle and a screen. Adjust the distance to form a real, inverted image on the screen. Varying the distance changes image size: closer to the candle (beyond 2F) produces a diminished image; at 2F, same size; between F and 2F, magnified. The water bag acts as a convex lens, converging light to form real images, demonstrating lens behavior.