Chapter 10: LIGHT – REFLECTION & REFRACTION

P10

1. State the laws of reflection of light.

i) The angle of incidence is equal to the angle of reflection.

ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie on the same plane.

2. State the properties of image formed by a plane mirror.

a) The image formed by the plane mirror is always virtual and erect.

b) The size of the image is equal to that of the object.

c) The image formed is as far behind the mirror as the object is in front of it.

d) The image is laterally inverted.

3. Differentiate between real image & virtual image.

Real Image	Virtual image
1. The rays actually meet at the image point.	1. The rays appear to diverge from the image point.
2. It can be taken on a screen.	2. It cannot be taken on the screen.
3. It is always inverted.	3. It is always erect.

4. What is lateral inversion?

The inversion of the left hand side of the object into the right hand side in the image and vice-versa is called lateral inversion.

5. (Activity 10.1) Take a large shining spoon. Try to view your face in its curved surface. Do you get the image? Is it smaller or larger?

Yes, the image of the face formed on outer curved surface is smaller in size.

Move the spoon slowly away from your face. Observe the image.

The size of image gradually decreases with an increase in field of view.

How does it change? Reverse the spoon and repeat the Activity.

Earlier, when the spoon was close the image formed on the inner curved surface was erect and magnified and as we moved the spoon slowly away from our face, the image transitioned to an inverted image with gradual decrease in its size.

How does the image look like now?
Compare the characteristics of the image on the two surfaces.

Outer surface	Inner surface
(i) Image is always erect.	(i) The image is erect when spoon is close and inverted when spoon is away
(ii) Image size is gradually decreases as we move away the spoon	(ii) Image size is larger when spoon is close and it is smaller when spoon is moved away

Why do we see our image in the shining spoon?

The surface of a shining spoon acts like a mirror. Due to reflection of light from its surfaces, we can see our image

What types of mirrors are formed by the inner and outer curved surfaces of a spoon?

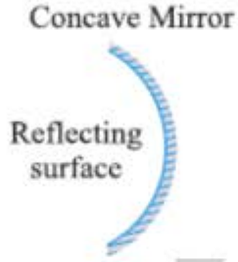
The inner curved surfaces of a spoon forms a concave mirror and the outer curved surfaces of a spoon forms a convex mirror

6. **What is a spherical mirror?**

A Mirror in which reflecting surfaces are spherical are called spherical mirror.

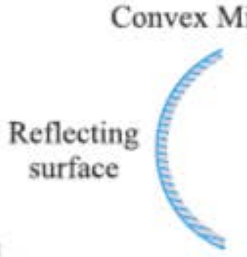
7. **What is a concave mirror?**

A spherical mirror, whose reflecting surface is curved inwards (faces towards the centre of the sphere) is called a concave mirror.



8. **What is a convex mirror?**

A spherical mirror whose reflecting surface is curved outwards, is called a convex mirror.



9. **Define the following with respect to a spherical mirror.**

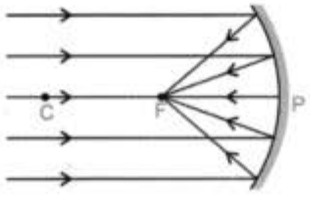
a) Pole of the mirror (P): The centre of the reflecting surface of a spherical mirror is a point called the pole.

b) Centre of curvature (C): The centre of the sphere of which the reflecting surface of a spherical mirror forms a part of a sphere.

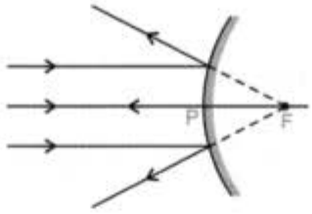
c) Radius of curvature (R): The radius of the sphere of which the reflecting surface of a spherical mirror forms a part, is called the radius of curvature of the mirror.

d) Principal axis: The straight line passing through the centre of curvature and pole of the spherical mirror, produced on both sides.

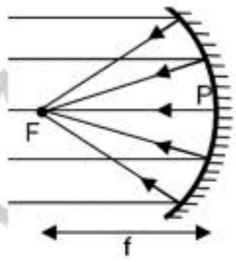
e) Focus of the concave mirror (F): The point on principal axis where all the parallel light rays after reflection actually meet at a point called focus.



f) Focus of the convex mirror (F): The point on principal axis where all the parallel light rays after reflection appear to meet at a point called focus.



g) Focal length (f): The distance between the pole of the mirror and principal focus.



h) Aperture: The diameter of the reflecting surface of the mirror is called aperture.

10. Is there a relationship between the radius of curvature R, and focal length f, of a spherical mirror?

Yes, the radius of curvature of a spherical mirror is twice the focal length. R=2f

11. (Activity 10.2) Hold a concave mirror in your hand and direct it's reflecting surface towards the Sun. Direct the light reflected by the mirror on to a sheet of paper held close to the mirror. Move the sheet of paper back and forth gradually until you find on the paper sheet a bright, sharp spot of light.

Hold the mirror and the paper in the same position for a few minutes. What do you observe? Why?

The light rays from the Sun, are concentrated at focus, and form a sharp spot of light on the sheet. Paper starts burning after some time due to increase intensity of reflected sun light from the mirror

Why, we should not look at the Sun directly or even into a mirror reflecting sunlight?

Because the intense heat resulting from the concentrated sun light through eye lens may burn the retina wall with dark spots. This may result in partial or complete vision impairment.

12. Draw ray diagram to show the image formation in a concave mirror & nature of the image when the object is placed:

a) At infinity

Nature:

b) Beyond C

Nature:

c) At C

Nature:

e) Between C and F

Nature:

f) At F

Nature:

g) Between P and F

Nature:

13. List four properties of the image formed by a concave mirror when object is placed between focus and pole of the mirror.

The image formed by a concave mirror is virtual, erect, enlarged and lies behind the mirror.

14. State the position of the object for which a concave mirror produces virtual magnified image.

The object should be placed between F and P of the concave mirror.

15. Explain why a ray of light passing through the centre of curvature of a concave mirror gets reflected along the same path.

A ray of light passing through the centre of curvature of the concave mirror falls normally ($\angle i = \angle r = 0^o$) on the mirror and so it is reflected back along the same path.

16. Mention the uses of concave mirror.

a) Concave mirror is used in torches, search lights and vehicle headlights to get powerful parallel beam of light.

b) They are used in shaving mirrors to see a larger image of the face.

c) Dentists use concave mirrors to see large images of the teeth of patients.

d) Large concave mirrors are used to concentrate sunlight to produce heat in solar furnace.

17. Give reason:

a) Concave mirror is used in headlight of vehicles.

Concave mirrors can produce powerful parallel beam of light when the light source is placed at their principal focus.

b) Concave mirror is used as shaving mirror.

To see a larger image of the face while shaving.

c) Dentists use concave mirror.

To see large images of the teeth of patients.

d) Concave mirrors are used in solar furnace.

To concentrate sunlight to produce heat.

18. (Activity 10.5) Take a convex mirror. Hold it in one hand. Hold a pencil in the upright position in the other hand. Observe the image of the pencil in the mirror.

Is the image erect or inverted? Is it diminished or enlarged?

The image is erect and diminished

Move the pencil away from the mirror slowly. Does the image become smaller or larger?

The image becomes smaller.

State whether the image will move closer to or farther away from the focus as the object is moved away from the mirror?

The image will move closer to the focus.

19. Draw ray diagram to show the image formation in a convex mirror & nature of the image when the object is placed:

a) At infinity

Nature:

b) Between infinity and the pole of the mirror.

Nature:

20. (Activity 10.6) Observe the image of a distant object, say a distant tree, in a plane mirror.

Could you see a full-length image?

No, we cannot see a full-length image of a distant object in a plain mirror.

Try with plane mirrors of different sizes. Did you see the entire object in the image?

No, we cannot see a full-length image of the distant object in a plain mirror.

Repeat this Activity with a concave mirror. Did the mirror show full length image of the object?

No, we cannot see a full length image in concave mirror.

Now try using a convex mirror. Did you succeed? Explain your observations with reason.

Yes, now we could see full length image of distant object with wider field of view. The image formed was diminished, erect and virtual.

21. Mention the use of convex mirror.

Convex mirror is used as rear-view mirror in vehicles.

22. Why do we prefer a convex mirror as a rear-view mirror in vehicles?

Convex mirrors are commonly used as rear-view (wing) mirrors in vehicles because they give an erect, virtual, full size diminished image of distant objects with a wider field of view. Convex mirrors enable the driver to view much larger area than would be possible with a plane mirror.

23. The radius of curvature of a spherical mirror is 20 cm. What is its focal length?

R=2f

20=2f

f=20/2= 10 cm

24. Name a mirror that can give an erect and enlarged image of an object.

Concave mirror gives an erect and enlarged image of an object, when the object is between pole and principal focus of mirror.

25. Write the sign Convention for Reflection by Spherical Mirror Or New Cartesian Sign Convention

i) The object is placed to the left of the mirror.

ii) All distances parallel to the principal axis are measured from the pole of the mirror.

iii) All distances measured in the direction of incident ray (along + X-axis) are taken as positive and those measured against the direction of incident ray (along – X-axis) are taken as negative.

iv) Distance measured perpendicular to and above the principal axis are taken as positive.

v) Distances measured perpendicular to and below the principal axis are taken as negative.

26. Define the following with respect to a spherical mirror.

a) Object distance (u): The distance of the object from its pole is called object distance.

b) Image distance (v): The distance of the image from the pole of the mirror is called image distance.

27. Write the mirror formula or the relation between the image distance, object distance and focal length.

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

28. Define magnification.

Magnification is the ratio of the height of the image to the height of the object.

$$m=\frac{\text{Height of the image } (h^{I})}{\text{Height of the object } (h)}=\frac{\text{Image distance } (v)}{\text{Object distance } (u)}$$

$$m=\frac{h^{I}}{h}=\frac{-v}{u}$$

29. What is the nature of the image formed by a concave mirror if the magnification produced by the mirror is +3?

As m is positive, the image is virtual and erect. It is 3 times larger than the object.

30. A convex mirror used for rear-view on an automobile has a radius of curvature of 3.00 m. If a bus is located at 5.00 m from this mirror, find the position, nature and size of the image.

R=+3m; u=-5m; v=?; h^{I}=?

f=R/2=+3/2=+1.5m

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}$$

$$\frac{1}{v}=\frac{1}{1.5}-\frac{1}{-5}=\frac{1}{1.5}+\frac{1}{5}=\frac{5+1.5}{7.5}=\frac{6.5}{7.5}=\frac{65}{75}=1.15\text{m}$$

The image is 1.15m at the back of the mirror.

Magnification $m=\frac{h^{I}}{h}=\frac{-v}{u}=\frac{1.15}{5}=+0.23$

The image is virtual, erect and smaller in size by a factor of 0.23

31. An object, 4.0 cm in size, is placed at 25.0 cm in front of a concave mirror of focal length 15.0 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and the size of the image.

h=+4cm, u=-25cm, f=-15cm, v=?, h^{I}=?

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}$$

$$\frac{1}{v}=\frac{1}{-15}-\frac{1}{-25}=\frac{1}{-15}+\frac{1}{25}=\frac{-5+3}{75}=\frac{-2}{75}=37.5cm$$

The screen should be placed at 37.5cm from the mirror. The image is real.

$$m=\frac{h^{I}}{h}=\frac{-v}{u}$$

$$h^{I}=\frac{-vh}{u}=\frac{(-37.5)(+4)}{-25}=-6.0cm$$

The image is inverted and enlarged.

32. Find the focal length of a convex mirror whose radius of curvature is 32 cm.

R=32cm

$$f=\frac{R}{2}=\frac{32}{2}=16cm$$

33. A concave mirror produces three times magnified (enlarged) real image of an object placed at 10 cm in front of it. Where is the image located?

m= - 3, u= - 10cm, v=?

$$m=\frac{-v}{u}$$

$$-3=\frac{-v}{-10}$$

$$v=-30cm$$

34. It is desired to obtain an erect image of an object, using a concave mirror of focal length 20cm.

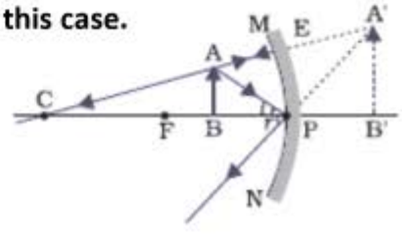
i) What should be the range of distance of the object from the mirror?

ii) Will the image be bigger or smaller than the object?

iii) Draw a ray diagram to show the image formation in this case.

i) The object should be placed between 0 to 20cm from the pole of the mirror.

ii) The image will be bigger than the object.



35. How do you distinguish between a plane, concave and convex mirrors without touching them?

Keep the face close to the mirror and then move away slowly from the mirror.

If the image formed is of the same size but laterally inverted for all positions, then it is a plane mirror.

If the image formed is erect and enlarged initially but gets inverted as the face is moved away then it is a concave mirror.

If the image formed is erect and smaller in size for all positions then it is convex mirror.

36. For the given data showing object distance and focal length of three concave mirrors, answer the following questions.

Sl. No.	Object distance (cm)	Focal length (cm)
1	30	20
2	10	15
3	20	10

i) Out of the three in which case the mirror will form the image having same size as the object?

Mirror at Sl. No. 3 will form the image of the same size as the object.

ii) Which mirror is being used as a make-up mirror?

Mirror at sl.No.2 can be used as a make-up mirror.

37. What happens when light enters from one transparent medium to another?

When light travels from one transparent medium to another medium, it tends to change its directions.

38. Why does the bottom of a tank or a pond containing water appears to be raised?

This is due to the refraction. The light rays pass through the air-water interface, they get bent due to refraction. The light rays are bent away from the normal making us perceive the bottom of the pond or tank as shallow or raised.

39. Why does a thick glass slab placed over some printed matter, the letters appear raised when viewed through the glass slab?

The letters appear raised because of a phenomenon known as refraction. When light travels from one medium to another, it bends (either towards or away from the normal). This happens because different media have different densities and thus, the speed of light is different in each one of them. This causes the light to slow down or speed up, depending on the medium.

40. Why does a lemon kept in water in a glass tumbler appears to be bigger than its actual size, when viewed from the sides.

Light is refracted as it passes from water into air. Tumbler with water acts as convex lens which curves outward in the middle and can focus light rays to magnify object.

41. A pencil partly immersed in water in a glass tumbler appears to be displaced at the interface of air and water.

The light reaching the eye from the portion of the pencil inside water seems to come from a different direction, compared to the part above water. This makes the pencil appear to be displaced at the interface.

42. What is refraction of light?

The change in direction of light when it passes from one medium to another obliquely is called refraction of light.

43. (Activity 10.7) Place a coin at the bottom of a bucket filled with water. With your eye to a side above water, try to pick up the coin in one go.

Did you succeed in picking up the coin?

No

Repeat the Activity. Why did you not succeed in doing it in one go?

Because on seeing, the coin appeared to be closer than its actual distance, so we are likely to miss the coin. Reflected light coming from the submerged coin in denser medium of water, on entering air which is a rarer medium, bend away from the normal due to refraction of light and image size becomes larger than its actual size, thus submerged object apparently seem closer.

(Activity 10.8) Place a large shallow bowl on a Table and put a coin in it. Move away slowly from the bowl. Stop when the coin just disappears from your sight. Ask a friend to pour water gently into the bowl without disturbing the coin. Keep looking for the coin from your position. Does the coin becomes visible again from your position? How could this happen?

Yes, on pouring water into the bowl, the coin becomes visible again because due to refraction of light, for our eyes, the submerged coin apparently seems raised above its actual level and thus becomes visible on seeing from the same side and distance.

44. (Activity 10.9) Draw a thick straight line in ink, over a sheet of white paper placed on a Table. Place a glass slab over the line in such a way that one of its edges makes an angle with the line.

1. Look at the portion of the line under the slab from the sides. What do you observe? Does the line under the glass slab appear to be bent at the edges?

Yes, due to the refraction of light, the line under the glass slab appear to be bent at the edges

2. Next, place the glass slab such that it is normal to the line. What do you observe now? Does the part of the line under the glass slab appear bent?

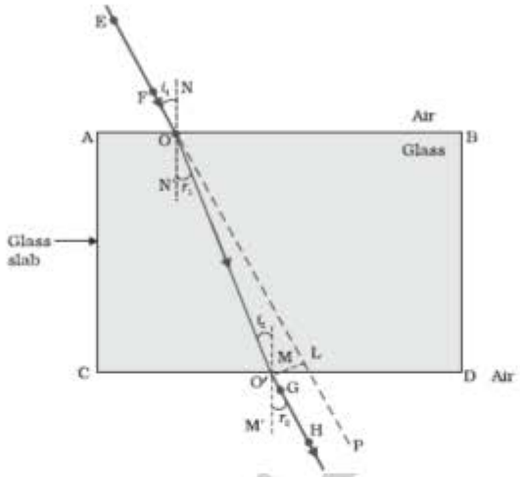
No, now the part of the line under the glass slab appear in a straight line. Because a ray of light, which is perpendicular to the plain of a refracting medium, does not change its angle due to refraction.

3. Look at the line from the top of the glass slab. Does the part of the line, beneath the slab, appear to be raised? Why does this happen?

Yes, the part of the line, beneath the slab, appear to be raised. Due to refraction of light, apparent position of image of object seems nearer than its actual position.

45. Fix a sheet of white paper on a drawing board using drawing pins. Place a rectangular glass slab over the sheet in the middle. Draw the outline of the slab with a pencil. Let us name the outline as ABCD. Take four identical pins.

Fix two pins, say E and F, vertically such that the line joining the pins is inclined to the edge AB. Look for the images of the pins E and F through the opposite edge. Fix two other pins, say G and H, such that these pins and the images of E and F lie on a straight line. Remove the pins and the slab. Join the positions of tip of the pins E and F and produce the line up to AB. Let EF meet AB at O. Similarly, join the positions of tip of the pins G and H and produce it up to the edge CD. Let HG meet CD at O'. Join O and O'. Also produce EF up to P, as shown by a dotted line in Fig. 10.10.



Question 1. What happens to incident ray as it enters the glass slab?

The incident ray as it enters from a rarer medium of air to a denser medium of glass, bends towards the normal, due to refraction of light. The refraction is caused by change in the speed of light as it enters from one transparent medium to another.

Question 2. What happens to emergent ray as it leaves the glass slab?

The emergent ray as it leaves the denser medium of glass and enters into a rarer medium of air, bends away from the normal, due to refraction of light. The refraction is caused by change in the speed of light as it enters from one transparent medium to another.

Question 3. What is the perpendicular distance between directions of incident and emergent rays?

Lateral displacement. This gives a measure of path deviation of refracted rays due to refraction.

Question 4. As given in the activity above, the medium of incidence and emergent ray is same (air), what could be the possible observations for angle of incidence and angle of emergence?

When the medium of incidence and emergent ray is same (air), angle of incidence is equal to angle of emergence.

46. State the laws of refraction of light.

(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

(ii) The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media.

47. State Snell's law of refraction.

The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media.

48. What is refractive index?

The refractive index of a medium is defined as the ratio of speed of light in vacuum to the speed of light in the medium. It is represented by n.

49. What is meant by absolute refractive index?

Refractive index of a medium with respect to vacuum or air.

50. Refractive index of water is 1.33 – Write the meaning of the statement.

The refractive index of water is 1.33. This means that the ratio of the speed of light in air and the speed of light in water is equal to 1.33.

51. Refractive index of grown glass is 1.52 – Write the meaning of the statement.

The refractive index of crown glass is 1.52. This means that the ratio of the speed of light in air and the speed of light in grown glass is equal to 1.52.

52. The refractive index of diamond is 2.42. What is the meaning of this statement?

The refractive index of diamond is 2.42. This means that the speed of light in diamond will reduce by a factor 2.42 compared to its speed in air.

Or

The ratio of the speed of light in air to the speed of light in diamond is 2.42.

53. Give an example to show that - an optically denser medium may not possess greater mass density.

Kerosene having higher refractive index, is optically denser than water, although its mass density is less than water.

54. When is a medium said to be optically denser?

The medium with the larger refractive index is optically denser medium.

55. When is a medium said to be optically rarer?

The medium with the lower refractive index is optically rarer medium.

56. A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal? Why?

The light ray bends towards the normal as it travels from a rarer medium of air to a denser medium of water, under goes refraction. Refraction is due to change in the speed of light as it enters from one transparent medium to another. The speed of light increases in rarer medium and decreases in denser medium.

57. Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is 3×10^8 ms^{-1}.

Speed of light in vacuum C = 3×10^8 ms^{-1}

Refractive index of glass ng = 1.50

Speed of light in the glass vg = ?

$$\text{Speed of light in glass, } v = \frac{c}{n_g} = \frac{3\times10^8}{1.5} = 2\times10^8$$

58. A ray of light incident obliquely on the surface of a rectangular glass slab emerges out of the opposite face undergoing some lateral displacement. How will the lateral displacement produced by the slab change on increasing the thickness of the slab?

Lateral displacement will increase with the increase in thickness of the glass slab.

59. A ray of light incident obliquely on a face of a rectangular slab placed in air, emerges from the opposite face parallel to the incident ray. State two factors on which the lateral displacement of the emergent ray depends.

Lateral displacement depends of i) angle of incidence ii) Thickness of the glass slab iii) Refractive index of the slab material.

60. The refractive index of diamond is 2.42 and the speed of light in air is 3 x 10 8 m/s. Calculate the speed of light in diamond.

61. Find out, from Table below, the medium having highest optical density. Also find the medium with lowest optical density.

Material medium	Refractive index		Material medium	Refractive index	Material medium	Refractive index
Air	1.0003		Fused quartz	1.46	Rock salt	1.54
Ice	1.31		Turpentine oil	1.47	Carbon disulphide	1.63
Water	1.33		Benzene	1.50	Dense flint glass	1.65
Alcohol	1.36		Crown glass	1.52	Ruby	1.71
Kerosene	1.44		Canada Balsam	1.53	Sapphire Diamond	1.77 2.42

The medium having highest optical density: Diamond (Refractive Index 2.42)

The medium having lowest optical density: Air (Refractive Index 1.0003)

62. You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in Table above

Using the information given in table, the refractive index of kerosene is 1.44, that of turpentine is 1.47 and that of water is 1.33. Water has lower refractive index 1.33, so it is optically rarer than kerosene and turpentine. Light travels fastest in water because of its lower optical density

63. The refractive index of alcohol and turpentine oil with respect to air are 1.36 and 1.47 respectively. Find the refractive index of turpentine oil with respect to alcohol. Which one of these will permit the light to travel faster?

64. What is a lens?

A lens is a transparent material bound by two surfaces, of which one or both surfaces are spherical.

65. What is a double convex or convex lens?

A lens having two spherical surfaces, bulging outwards is called a double convex lens or a convex lens. It is thicker at the middle and thinner at the edges. It is also called as converging lens.

66. What is a concave lens?

A lens which is bounded by two spherical surfaces, curved inwards is called concave lens. It is thicker in the edges and thinner in the middle. It is also called diverging lens.

67. Define the following with respect to a lens.

a) Optic centre (O): The centre point of a lens is called the optic centre.

b) Centre of curvature (C): The centre of the spheres of which the lens forms a part.

c) Radius of curvature (R): The radius of the sphere of which lens forms a part is called the radius of curvature of the lens.

d) Principal axis: The imaginary straight line passing through the two centres of curvature is called principal axis.

e) Principal focus of convex lens (F): The point on principal axis where all the parallel light rays after refraction actually meet at a point called focus.

f) Principal focus of concave lens (F): The point on principal axis where all the parallel light rays after refraction appear to meet at a point called focus.

g) Focal length (f): The distance of the principal focus from the optical centre of the lens is called focal length.

h) Aperture: The diameter of the circular outline of a lens is called aperture.

68. (Activity 10.11) Hold a convex lens in your hand. Direct it towards the Sun. Focus the light from the Sun on a sheet of paper. Obtain a sharp bright image of the Sun. Hold the paper and the lens in the same position for a while. Keep observing the paper. What happened? Why?

The paper begins to burn producing smoke. If we still hold the paper and the lens in the same position for some more time, the paper may even catch fire.

The parallel rays of light from the sun are converged by the lens at the sharp bright spot formed on the paper. The concentration of the sunlight at a point generated heat. The bright spot is the real image of the sun.

69. Draw ray diagram to show the image formation in a convex lens & nature of the image when the object is placed:

a) At infinity

Nature:

b) Beyond $2F_1$

Nature:

c) At $2F_1$

Nature:

f) Between F_1 and $2F_1$

Nature:

f) At F_1

Nature:

g) Between F_1 and O

Nature:

70. Draw ray diagram to show the image formation in a concave lens & nature of the image when the object is placed:

a) At infinity

Nature:

b) Between infinity and optic centre (O)

Nature:

71. Distinguish between a concave and convex lens.

Convex Lens	Concave lens
1. It is thicker at the centre than at the edges.	1. It is thinner at the centre than at the edges.
2. It converges parallel beam of light on refraction through it.	2. It diverges a parallel beam of light on refraction through it.
3. It has a real focus.	3. It has a virtual focus.

72. Write the sign convention of the object distance, image distance and focal length of convex lens and concave lens.

	Convex lens	**Concave lens**
Object distance (u)	–	–
Image distance (v)	+	–
Focal length (f)	–	–

73. Write the lens formula.

Lens formula gives the relationship between object distance (u) and image distance (v)

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

74. Define magnification of lens.

Magnification is the ratio of the height of the image to the height of the object. –

$$m=\frac{\text{Height of the image}}{\text{Height of the object}}=\frac{h^{l}}{h}=\frac{v}{u}$$

75. A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also, find the magnification produced by the lens.

76. A 2.0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 10 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. Also find its magnification.

77. Define power of a lens.

Power of a lens is defined as the reciprocal of its focal length. $P=\frac{1}{f}$

78. How is focal length and power of a lens related?

A lens of short focal length has more power.

79. State the SI unit of power of lens.

Dioptre (D)

80. Define one dioptre.

One dioptre is the power of a lens whose focal length is 1 metre. $1D=1m^{-1}$

81. An optician prescribe corrective lenses indicating + 2.0 D. Write the meaning of the statement.

Lens of +2.0 D means the lens prescribed is convex. The focal length of the lens is +0.50m.

82. An optician prescribe corrective lenses indicating - 2.5 D. Write the meaning of the statement.

Lens of -2.5 D means the lens prescribed is concave. The focal length of the lens is -0.40m.

83. A lens X has focal length 20cm and lens Y has focal length 40cm. Which lens would you select to obtain a more convergent beam of light?

The lens X of smaller focal length is used to obtain a more convergent beam of light. Smaller the focal length, larger is the converging power of the lens.

84. Why do we use lens combinations in various optical instruments?

i) To increase the magnification of the image. ii) To increase the sharpness of the image iii) To erect the final image iv) To minimise certain defects or aberrations in the image formed by a single lens.

85. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also, find the power of the lens.

It is given that the image of the needle is formed at a distance of 50 cm from the convex lens. Hence, the needle is placed in front of the lens at a distance of 50cm.

Object distance, u = −50 cm

Image distance, v = 50 cm

Focal length = f

According to the lens formula,

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{f}=\frac{1}{50}-\frac{1}{-50}=\frac{1}{50}+\frac{1}{50}=\frac{2}{50}=\frac{1}{25}$$

$$f=25cm=0.25m$$

$$\text{Power of lens, } P=\frac{1}{f}=\frac{1}{0.25}=+4D$$

86. Find the power of a concave lens of focal length 2 m.

Focal length of concave lens, f = 2 m

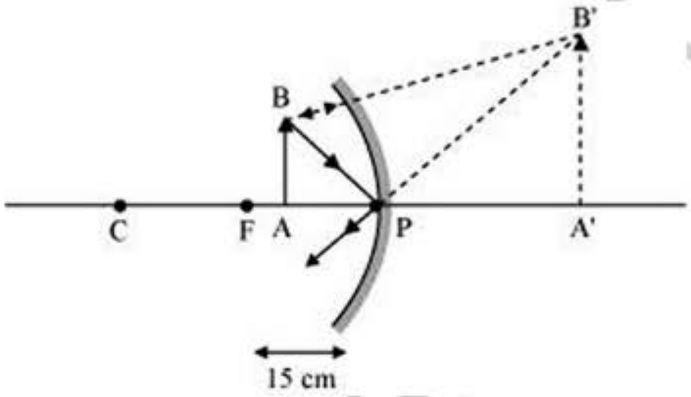
$$\text{Power of the lens, } P=\frac{1}{f}=\frac{1}{-2}=-0.5D$$

87. We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

Range of object distance = 0 cm to15 cm

A concave mirror gives an erect image when an object is placed between its pole (P) and the principal focus (F).

To obtain an erect image of an object from a concave mirror of focal length 15 cm, the object must be placed anywhere between the pole and the focus. The image formed will be virtual, erect, and magnified in nature, as shown in the given figure.



88. Name the type of mirror used in the following situations. Support your answer with reason.

(a) Headlights of a car.

Concave. This is because concave mirrors can produce powerful parallel beam of light when the light source is placed at their principal focus.

(b) Side/rear-view mirror of a vehicle.

Convex mirrors give a virtual, erect, and diminished image of the objects placed in front of it. They have a wide field of view. It enables the driver to see most of the traffic behind him/her.

(c) Solar furnace.

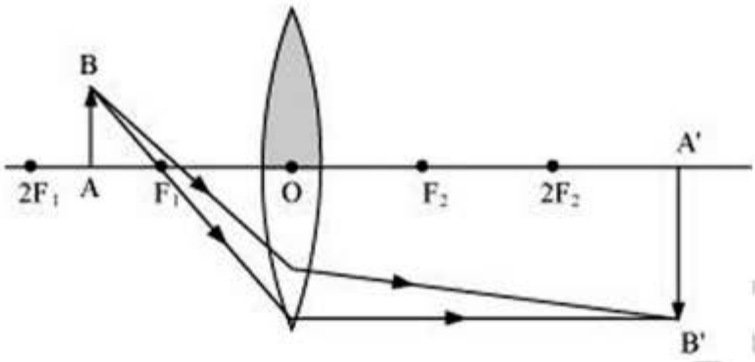
Concave mirrors are convergent mirrors. Concave mirrors converge the light incident on them at a single point known as principal focus. Hence, they can be used to produce a large amount of heat at that point.

89. One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

The convex lens will form complete image of an object, even if it's one half is covered with black paper. It can be understood by the following two cases.

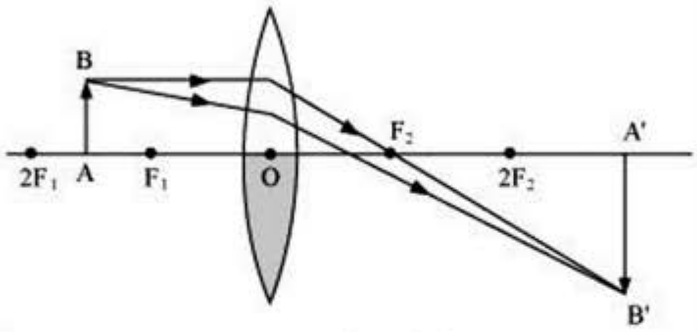
Case I: When the upper half of the lens is covered

In this case, a ray of light coming from the object will be refracted by the lower half of the lens. These rays meet at the other side of the lens to form the image of the given object, as shown in the following figure.



Case II: When the lower half of the lens is covered

In this case, a ray of light coming from the object is refracted by the upper half of the lens. These rays meet at the other side of the lens to form the image of the given object, as shown in the following figure.



90. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed.

Object distance, u = −25 cm

Object height, ho = 5 cm

Focal length, f = +10 cm

According to the lens formula,

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}=\frac{1}{f}+\frac{1}{u}=\frac{1}{10}-\frac{1}{25}=\frac{5-2}{50}=\frac{3}{50}$$

$$v=\frac{50}{3}=16.67\text{cm}$$

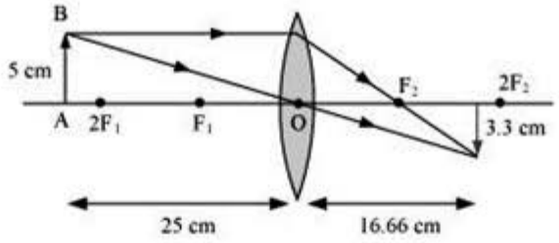
The positive value of v shows that the image is formed at the other side of the lens.

$$m=\frac{v}{u}=\frac{16.67}{-25}=-0.67$$

The negative sign shows that the image is real and formed behind the lens.

$$m=\frac{h^{l}}{h}=\frac{v}{u}=-0.67$$

$$h^{l}=-5x0.67=-3.3\text{cm}$$



91. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

Focal length of concave lens f = −15 cm

Image distance, v = −10 cm

According to the lens formula,

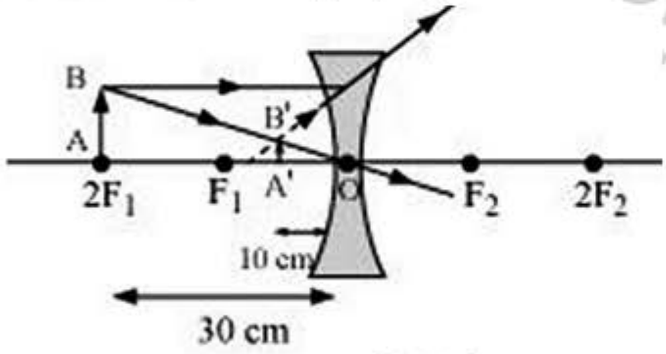
$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{u}=\frac{1}{v}-\frac{1}{f}$$

$$\frac{-1}{10}+\frac{1}{15}=\frac{-3+2}{30}=\frac{-1}{30}$$

$$u=-30\text{cm}$$

The negative value of u indicates that the object is placed 30 cm in front of the lens. This is shown in the following ray diagram.



92. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

Focal length of convex mirror, f = +15 cm; Object distance, u = −10 cm

According to the mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{15}+\frac{1}{10}=\frac{2+3}{30}=\frac{5}{30}=\frac{1}{6}$$

$$v=6\text{cm}$$

The positive value of v indicates that the image is formed behind the mirror.

$$\text{Magnification } m=-\frac{v}{u}=\frac{6}{-10}=+0.6$$

The positive value of magnification indicates that the image formed is virtual and erect.

93. The magnification produced by a plane mirror is +1. What does this mean?

The magnification produced by a plane mirror is +1. It shows that the image formed by the plane mirror is of the same size as that of the object. The positive sign shows that the image formed is virtual and erect.

94. An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.

95. Object distance, u = −20 cm

Object height, h = 5 cm; Radius of curvature, R = 30 cm; R = 2f; f = 15 cm

According to the mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{15}+\frac{1}{20}=\frac{4+3}{60}=\frac{7}{60}$$

$$v=\frac{60}{7}=8.57\text{cm}$$

The positive value of v indicates that the image is formed behind the mirror.

$$m=-\frac{v}{u}=\frac{8.57}{-20}=+0.428$$

The positive value of magnification indicates that the image formed is virtual and erect.

$$m=-\frac{h_2}{h_1}$$

$$+0.428=\frac{h_2}{5}$$

$$h_2=0.428\times 5=+2.14\text{cm}$$

The positive value of image height indicates that the image formed is erect.

The image formed is virtual, erect, and smaller in size.

96. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focussed image can be obtained? Find the size and the nature of the image.

Object distance, u = −27 cm; Object height, h = 7 cm ; Focal length, f = −18 cm

According to the mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{-1}{18}+\frac{1}{27}=\frac{-3+2}{54}=\frac{-1}{54}$$

$$v=54\text{cm}$$

The screen should be placed at a distance of 54 cm in front of the given mirror.

$$m=-\frac{v}{u}=-\frac{-54}{-27}=-2$$

The negative value of magnification indicates that the image formed is real.

$$m = \frac{h_2}{h_1}$$

$$-2 = \frac{h_2}{7}$$

$$h_2 = -2 \times 7 = -14\text{cm}$$

The negative value of image height indicates that the image formed is inverted.

97. Find the focal length of a lens of power – 2.0 D. What type of lens is this?

$$P = \frac{1}{f}$$

$$f = \frac{1}{P} = \frac{-1}{2} = -0.5\text{m}$$

A concave lens has a negative focal length. Hence, it is a concave lens.

98. A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

Power of the lens

$$P = \frac{1}{f}$$

$$f = \frac{1}{P} = \frac{1}{1.5} = \frac{10}{15} = 0.66\text{m}$$

A convex lens has a positive focal length. Hence, it is a convex lens or a converging lens.

99. An object of size 5cm is placed at a distance of 25cm from the pole of a concave mirror of radius of curvature 30cm. Calculate the distance and size of the image formed. What will be the nature of the image?

100. An object 3cm high is placed at a distance of 8cm from a concave mirror which produces a virtual image 45cm high. What is the focal length of the mirror? Also find the position of the image.

101. A convex mirror used on a moving automobile has a radius of curvature of 3.0cm. If a truck following it at a constant distance of 4.5m, find the i) position ii) the nature iii) magnification for the image.

102. How far should on hold an object from a concave mirror of focal length 40cm so as to get a virtual image twice the size of the object?

103. A concave mirror produces three times enlarged image of an object placed at 10cm in front of it. Calculate the radius of curvature of the mirror.

104. A convex lens of focal length 10cm is placed at a distance of 12cm from a wall. Calculate the distance from the lens where an object be placed so as to form its distinct real image on the wall.

105. A 5cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20cm. The distance of the object from the lens is 30cm. Find the nature, position and size of the image. Also find its magnification.

106. **An object 2cm high is placed at a distance of 64cm from the screen. On placing a convex lens 32cm from the object it is found that a distinct image of the object is formed on the screen. What is the focal length of the convex lens and size of the image formed on the screen?**

107. **An object of height 4cm is kept at a distance of 30cm from a concave lens. Use the lens formula to determine the image distance, nature and size of the image formed if focal length of the lens is 15cm.**

108. **The image of an object formed by a convex lens, at what distance from the lens is the object placed? Find the focal length and power of the lens used.**

109. **A thin lens has a focal length of –50cm. What is the power of the lens and its nature?**

110. Two thin lenses of power +3.5D and – 2.5D are placed in contact. Find the power and focal length of the lens combination.

111. An object of height 4cm is placed at a distance of 15cm in front of a concave lens of power – 10D. Find the size of the image.

Fill in the blanks:

1) A mirror whose reflecting surface are spherical is called spherical mirror.
2) A spherical mirror whose reflecting surface is curved inwards is called concave mirror.
3) A spherical mirror whose reflecting surface is curved outwards is called convex mirror.
4) The centre of the reflecting surface of a spherical mirror is called pole.
5) Pole of the mirror lies on the surface of a spherical mirror.
6) The centre of the spherical mirror of which the reflecting surface is a part is called centre of curvature.
7) The centre of curvature lies outside its reflecting surface.
8) The radius of the sphere of which the reflecting surface of a spherical mirror forms a part, is called the radius of curvature of the mirror.
9) The straight line passing through the centre of curvature and pole of the spherical mirror is called focal length.
10) The diameter of the reflecting surface of the mirror is called aperture.
11) Radius of curvature is twice the focal length.
12) The type of mirror used in torch light/search light/headlight of car is concave.
13) The type of mirror used in shaving mirror is concave.
14) The type of mirror used by dentists is concave.
15) The type of mirror used in solar furnace is concave.
16) The type of mirror used as rear-view mirror in vehicles is convex mirror.
17) The type of mirror that enable the driver to view much larger area is convex mirror.

18) The distance of the object from its pole is called object distance.

19) The distance of the image from the pole of the mirror is called image distance.

20) The ratio of speed of light in vacuum to the speed of light in the medium is called refractive index.

21) Refractive index of a medium with respect to vacuum or air is called absolute refractive index.

22) The speed of light is higher in a rarer medium.

23) A ray of light travelling from a rarer medium to a denser medium slows down and bends towards the normal.

24) A ray of light travelling from a denser medium to a rarer medium speeds up and bends away from the normal.

25) The medium with the larger refractive index is optically denser medium.

26) The medium with the lower refractive index is optically rarer medium.

27) A transparent material bound by two surfaces, of which one or both surfaces are spherical is called a lens.

28) A lens having two spherical surfaces, bulging outwards is called a convex lens.

29) The ability of the lens to converge or diverge light rays depends on its focal length.

30) A convex lens of short focal length bends the light rays through larger angles.

Multiple choice questions

1) Which one of the following materials cannot be used to make a lens?

(a) Water (b) Glass (c) Plastic **(d) Clay**

2) The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

(a) Between the principal focus and the centre of curvature

(b) At the centre of curvature

(c) Beyond the centre of curvature

(d) Between the pole of the mirror and its principal focus.

3) Where should an object be placed in front of a convex lens to get a real image of the size of the object?

(a) At the principal focus of the lens

(b) At twice the focal length

(c) At infinity

(d) Between the optical centre of the lens and its principal focus.

4) A spherical mirror and a thin spherical lens have each a focal length of –15 cm. The mirror and the lens are likely to be

(a) both concave.

(b) both convex.

(c) the mirror is concave and the lens is convex.

(d) the mirror is convex, but the lens is concave.

5) No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be

(a) plane. (b) concave.

(c) convex. **(d) either plane or convex.**

6) Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

(a) A convex lens of focal length 50 cm. (b) A concave lens of focal length 50 cm.

(c) A convex lens of focal length 5 cm. (d) A concave lens of focal length 5 cm.

7) Which of the following can make a parallel beam of light when light from a point source is incident on it?

(a) Concave mirror as well as convex lens

(b) Convex mirror as well as concave lens

(c) Two plane mirrors placed at 90° to each other

(d) Concave mirror as well as concave lens

8) A 10 mm long awl pin is placed vertically in front of a concave mirror. A 5 mm long image of the awl pin is formed at 30 cm in front of the mirror. The focal length of this mirror is

(a) – 30 cm **(b) – 20 cm** (c) – 40 cm (d) – 60 cm

9) Under which of the following conditions a concave mirror can form an image larger than the actual object?

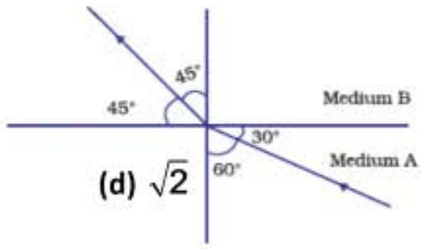
(a) When the object is kept at a distance equal to its radius of curvature

(b) When object is kept at a distance less than its focal length

(c) When object is placed between the focus and centre of curvature

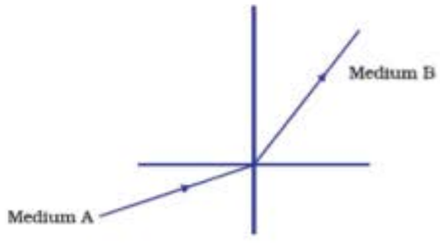
(d) When object is kept at a distance greater than its radius of curvature

10) Figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is:



(a) $\frac{\sqrt{3}}{\sqrt{2}}$ (b) $\frac{\sqrt{2}}{\sqrt{3}}$ (c) $\frac{1}{\sqrt{2}}$ **(d) $\sqrt{2}$**

11) A light ray enters from medium A to medium B as shown in Figure. The refractive index of medium B relative to A will be



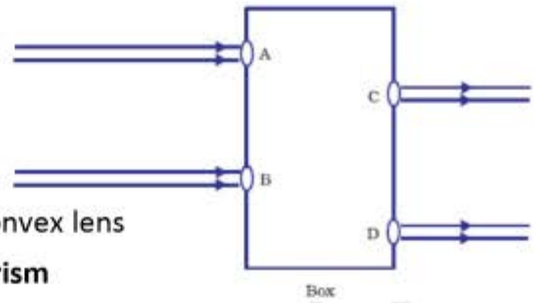
(a) greater than unity

(b) less than unity

(c) equal to unity

(d) zero

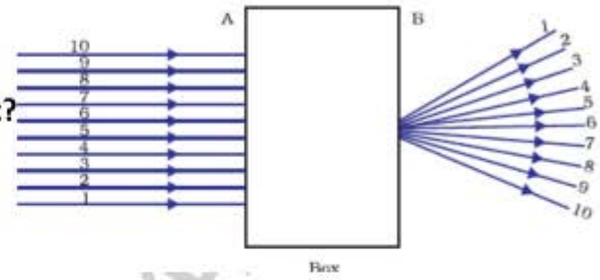
12) **Beams of light are incident through the holes A and B and emerge out of box through the holes C and D respectively as shown in the Figure10.3. Which of the following could be inside the box?**



(a) A rectangular glass slab (b) A convex lens

(c) A concave lens **(d) A prism**

13) **A beam of light is incident through the holes on side A and emerges out of the holes on the other face of the box as shown in the Figure. Which of the following could be inside the box?**



(a) Concave lens

(b) Rectangular glass slab

(c) Prism

(d) Convex lens

14) **Which of the following statements is true?**

(a) A convex lens has 4 dioptre power having a focal length 0.25 m

(b) A convex lens has –4 dioptre power having a focal length 0.25 m

(c) A concave lens has 4 dioptre power having a focal length 0.25 m

(d) A concave lens has –4 dioptre power having a focal length 0.25 m

15) **Magnification produced by a rear view mirror fitted in vehicles**

(a) is less than one (b) is more than one

(c) is equal to one

(d) can be more than or less than one depending upon the position of the object in front of it

16) **Rays from Sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object?**

(a) 15 cm in front of the mirror **(b) 30 cm in front of the mirror**

(c) between 15 cm and 30 cm in front of the mirror

(d) more than 30 cm in front of the mirror

17) **A full length image of a distant tall building can definitely be seen by using**

(a) a concave mirror **(b) a convex mirror**

(c) a plane mirror (d) both concave as well as plane mirror

18) **In torches, search lights and headlights of vehicles the bulb is placed**

(a) between the pole and the focus of the reflector

(b) very near to the focus of the reflector

(c) between the focus and centre of curvature of the reflector

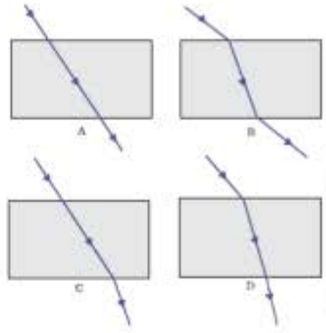
(d) at the centre of curvature of the reflector

19) The laws of reflection hold good for

(a) plane mirror only (b) concave mirror only

(c) convex mirror only **(d) all mirrors irrespective of their shape**

20) The path of a ray of light coming from air passing through a rectangular glass slab traced by four students are shown as A, B, C and D in Figure 10.5. Which one of them is correct?



(a) A

(b) B

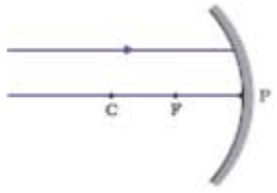
(c) C

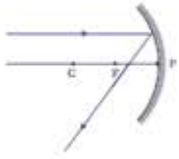
(d) D

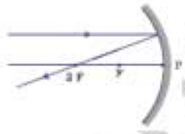
21) You are given water, mustard oil, glycerine and kerosene. In which of these media a ray of light incident obliquely at same angle would bend the most?

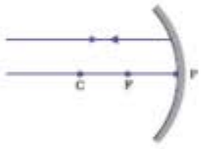
(a) Kerosene (b) Water (c) Mustard oil **(d) Glycerine**

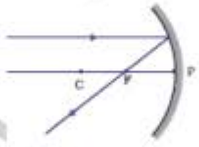
22) Which of the following ray diagrams is correct for the ray of light incident on a concave mirror as shown in Figure?



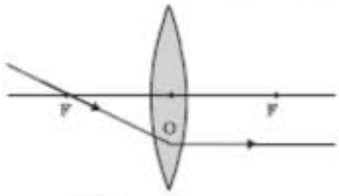
(a) 

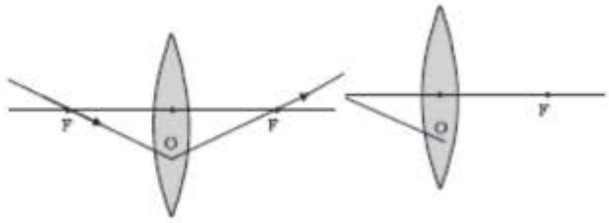
(b) 

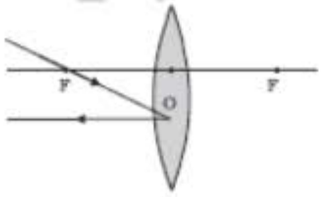
(c) 

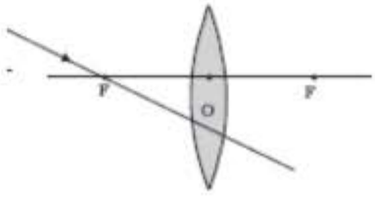
(d) 

23) Which of the following ray diagrams is correct for the ray of light incident on a lens shown in Figure?

(a) 

(b) 

(c) 

(d) 

(a) Fig. A. (b) Fig. B. (c) Fig. C. (d) Fig. D.

24) A child is standing in front of a magic mirror. She finds the image of her head bigger, the middle portion of her body of the same size and that of the legs smaller. The following is the order of combinations for the magic mirror from the top.

(a) Plane, convex and concave (b) Convex, concave and plane

(c) Concave, plane and convex (d) Convex, plane and concave

25) In which of the following, the image of an object placed at infinity will be highly diminished and point sized?

(a) Concave mirror only (b) Convex mirror only

(c) Convex lens only

(d) Concave mirror, convex mirror, concave lens and convex lens

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