EXERCISE 5(C)

Solution:

The axis along which the distances are measured is called as the principal axis. These distances are measured from the optical centre of the lens.

The distances measured in the same direction as that of incident light are taken as positive

The distances measured against the direction of incident light are taken as negative

The distances measured upward and perpendicular to the principal axis are taken as positive

The distances measured downwards and perpendicular to principal axis is taken as negative

The focal length of the convex lens is taken as positive and that of concave lens is taken as negative

Solution:

(i) If the focal length of a lens is positive, then the lens is convex lens

(ii) If the focal length of a lens is negative, then the lens is concave lens

Lens formula

$$1 / v - 1 / u = 1 / f$$

where ‘u’ is the distance of the object from the optical center of the lens

‘v’ is the distance of the image from the optical center while ‘f’ is the focal length, the distance between the optical center and the focus of the lens.

Solution:

The term magnification is defined as the ratio of the size of the image to the size of the object. The expression is

$$m = -v / u \text{ or}$$

m =Height of image (h') / Height of object (h) where v means image distance and u means object distance
h' means size of the image or h means size of the object

Solution:
(i) The positive magnification indicates that the image formed is virtual while negative sign indicates that the image formed is real.
(ii) The positive magnification indicates that the image formed is erect while negative sign indicates that the image formed is inverted

Question: 6
Define the term power of a lens. In what unit is it expressed?
Solution:
Power of lens is the ability of the lens to converge the rays of light falling on it or it is defined as P = 1 / f where f is the focal length. The S.I unit of power is Dioptre (D)

Question: 7
How is the power of a lens related to its focal length?
Solution:
The power of a lens is related to its focal length as
P = 1 / f or
Power of lens (in D) = 1 / focal length (in metre)
Therefore its inversely proportional to focal length

Question: 8
How does the power of a lens change if its focal length is doubled?
Solution:
Power is inversely proportional to the focal length. So if the focal length is doubled, the power is reduced by half.

Question: 9
How is the sign (+ or -) of power of a lens related to its divergent or convergent action?
Solution:
The sign of power depends on the direction in which a light ray is deviated by the lens. The power could be positive or negative. If a lens deviates a ray towards its centre

(converges), the power is positive and if it deviates the ray away from its centre (diverges), the power is negative.

Question: 10
The power of a lens is negative. State whether it is convex or concave?
Solution:
It is a concave lens

Question: 11
Which lens has more power: a thick lens or a thin lens?
Solution:
A thick lens has more power than a thin one because it has greater curvature or lesser focal length than a thin lens

MULTIPLE CHOICE TYPE
Question: 1
If the magnification produced by a lens is - 0.5, the correct statement is :
(a) The lens is concave
(b) The image is virtual
(c) The image is magnified
(d) The images is real and diminished formed by a convex
Solution:
The correct statement is the image is real and diminished formed by a convex lens because negative sign of magnification indicates that the image is real while o.5 indicates that the image is diminished.

Question: 2
The correct lens formula is
(a) 1 / u + 1 / v = 1 / f
(b) 1 / u – 1 / v = 1 / f
(c) 1 / v – 1 / u = 1 / f
(d) f = (u + v) / uv
Solution:
The correct lens formula is

$$1 / v – 1 / u = 1 / f$$

Question: 3
On reducing the focal length of a lens, its power:
(a) Decreases
(b) Increases
(c) Does not change
(d) First increases then decreases.
Solution:
On reducing the focal length of a lens, its power increases.

Question: 4
The lens of power + 1.0 D is :
(a) convex of focal length 1.0 cm
(b) convex of focal length 1.0 m
(c) concave of focal length 1.0 cm
(d) concave of focal length 1.0 m
Solution:
Power lens is + 1.0 D. Here positive sign indicates that the focal length of the lens is positive which indicates that it is a convex lens

Power is P = 1 / f (in m)
+1.0 D = 1 / f (in m)
f = 1.0 m

Therefore the lens of power +1.0 D is 1.0 m

NUMERICALS
Question: 1
(a) At what position a candle of length 3 cm be placed in front of a convex lens so that its image of length 6 cm be obtained on a screen placed at distance 30 cm behind the lens?
(b) What is the focal length of lens in part (a)?
Solution:

Given
Height of a candle (object) = 3 cm
Height of the image of the candle = 6 cm
Image distance = 30 cm
(a) The formula for magnification of a lens is
m = h' / h
m = v / u
6 / 3 = 30 / u
∴ u = 15 cm

(b) Lens formula is
1 / v – 1 / u = 1 / f
∴ 1 / 30 – 1 / -15 = 1 / f [u is negative]
∴ 1 / f = 1 / 30 + 1 / 15
1 / f = 3 / 30
∴ f = + 10 cm

Question: 2
A concave lens forms the image of an object kept at a distance 20 cm in front of it, at a distance 10 cm on the side of the object.
(a) What is the nature of the image?
(b) Find the focal length of the lens.
Solution:
Given,
Object distance, u = -20 cm
Image distance, v = - 10 cm
(a) It is a virtual image because the image is formed on the same side as the object. Also, since the lens is a concave lens the image will be erect and diminished.
(b) Lens formula is
1 / v – 1 / u = 1 / f
∴ 1 / -10 – 1 / -20 = 1 / f
∴ 1 / f = 1 / 20 – 1 / 10
∴ 1 / f = - 1 / 20
∴ f = - 20 cm

Question: 3
The focal length of a convex lens is 25 cm. At what distance from the optical centre of the lens an object be placed to obtain a virtual image of twice the size?
Solution:
Given,
Focal length, f = +25 cm
Image is virtual and magnified, m = +2
For a lens, magnification is
m = v / u
∴ +2 = v / u
∴ v = 2u
Lens formula is,
1 / v – 1 / u = 1 / f
∴ 1 / 2u – 1 / u = 1 / 25

∴ - 1 / 2u = 1 / 25
∴ 2u = - 25
∴ u = - 12.5 cm

Question: 4
Where should an object be placed in front of a convex lens of focal length 0.12 m to obtain a real image of size three times the size of the object, on the screen?
Solution:

Given,
Focal length of a convex lens, f = + 0.12 m
m = -3 (real image)
For a lens, magnification is
m = v / u
∴ - 3 = v / u
∴ v = - 3u
Lens formula is,
1 / v – 1 / u = 1 / f
∴ 1 / - 3u – 1 / u = 1 / 0.12
∴ -4 / 3u = 1 / 0.12
∴ 3u = 0.48 m
∴ u = 0.48 / 3
∴ u = - 0.16 m

Question: 5
An illuminated object lies at a distance 1.0 m from a screen. A convex lens is used to form the image of object on a screen placed at distance 75 cm from the lens. Find: (i) the focal length of lens, and (ii) the magnification.
Solution:

Given,
Image distance, v = 75 cm
Object distance, u = -25 cm
Lens formula is,
1 / v – 1 / u = 1 / f
∴ 1 / 75 – 1 / -25 = 1 / f
∴ 1 / f = 1 / 75 + 1 / 25
∴ 1 / f = 4 / 75
∴ f = 75 / 4
∴ f = 18.75 cm

For a lens, magnification is

m = v / u
∴ m = 75 / -25
∴ m = -3

Question: 6
A lens forms the image of an object placed at a distance 15 cm from it, at a distance 60 cm in front of it. Find: (i) the focal length, (ii) the magnification, and (iii) the nature of image.
Solution:

Given,
Object distance, u = - 15 cm
Image distance, v = - 60 cm
(i) Lens formula is,
1 / v – 1 / u = 1 / f
∴ 1 / - 60 – 1 / - 15 = 1 / f
∴ 1 / f = 1 / 15 – 1 / 60
∴ 1 / f = 3 / 60
∴ f = 60 / 3
∴ f = 20 cm

For a lens, magnification is
m = v / u
∴ m = - 60 / - 15
∴ m = +4
(iii) The nature of the image is erect, virtual and magnified.

Question: 7
A lens forms the image of an object placed at a distance of 45 cm from it on a screen placed at a distance 90 cm on other side of it. (a) name the kind of lens. (b) find: (i) the focal length of lens, (ii) the magnification of image.
Solution:

Given,
Object distance, u = - 45 cm
Image distance, v = + 90 cm
(a) The image is real since the image is formed on the other side of the lens. Hence, the lens is a convex lens.
(b)
(i) Lens formula is,
1 / v – 1 / u = 1 / f
∴ 1 / 90 – 1 / - 45 = 1 / f

∴ 1 / f = 1 / 90 + 1 / 45
∴ 1 / f = 3 / 90
∴ f = 30 cm

(ii) For a lens, magnification is

m = v / u
∴ m = 90 / - 45
∴ m = - 2

Question: 8

An object is placed at a distance of 20 cm in front of a concave lens of focal length 20 cm. find: (a) the position of image, and (b) the magnification of image

Solution:

Given,
Object distance, u = - 20 cm
Focal length, f = - 20 cm (concave lens)
(a) Lens formula is,
1 / v – 1 / u = 1 / f
∴ 1 / v = 1 / f + 1 / u
∴ 1 / v = 1 / - 20 + 1 / - 20
∴ 1 / v = - 2 / 20
∴ v = -10 cm

Hence the image is 10 cm in front of the lens on the same side as the object.

(ii) For a lens, magnification is

m = v / u
∴ m = -10 / - 20
∴ m = + 0.5

Question: 9

A convex lens forms an inverted image of size same as that of the object which is placed at a distance 60 cm in front of the lens. Find:
(a) The position of image, and
(b) The focal length of the lens

Solution:

A convex lens forms an inverted, real and an image of the same size as the object when the object is placed at 2f i.e u = 2f

(a) In such cases, the image is formed at the point which is double the focal length on the other side of the lens ($2f_2$)

(b) To find the focal length of this lens, we use the relationship

Object distance (u) = 2f

Object distance = 60 cm (given)
60 = 2f
f = 60 / 2
f = 30
Hence, the focal length of this lens is 30 cm

Question: 10
A concave lens forms an erect image of 1/3rdsize of the object which is placed at a distance 30 cm in front of the lens. Find:
(a) The position of image, and
(b) The focal length of the lens.
Solution:
Given,
Distance of the object u = - 30 cm
Magnification m = h'/ h
= 1 / 3
We know that
The magnification is
m = h' / h
m = v / u
1 / 3 = v / -30
v = -10 cm
Therefore the image is formed at 10 cm from the lens.
Len's formula is
1 / f = 1 / v – 1 / u
1 / f = 1 / - 15
f = -15 cm
Hence, the focal length is 15 cm and the image is formed at 10 cm from the lens.

Question: 11
The power of a lens is +2.0 D. Find its focal length and state what kind of lens it is?
Solution:
Given,
Power of the lens = +2D
Since the power is positive,
∴ The lens is convex
Let focal length be F
Power = 1 / F
2 = 1 / F

F = 1 / 2 m
F = 0.5 m
∴ The focal length is 0.5 m and the lens is convex lens

Question: 12
Express the power (with sign) of a concave lens of focal length 20 cm.
Solution:
P = 1 / F (in metre)
P = 1 / 0.2 m
P = 5D
As it is a concave lens so power is negative
Therefore P = - 5D

Question: 13
The focal length of a convex lens is 25 cm. Express its power with sign.
Solution:
Given,
Focal length, f = +25 cm
= +0.25 m
We need to find the power
P = 1 / f
P = 1 / +0.25
P = +4.0 D

Question: 14
The power of a lens is -2.0 D. Find its focal length and its kind.
Solution:
Given,
The power of a lens = -2.0 D
Power of a lens is
P = 1 / f
-2 = 1 / f
f = 1 / -2
f = -0.5 m
f = - 50 cm
As power is negative it indicates that the lens is a concave lens

Question: 15
The magnification by a lens is -3. Name the lens and state how are u and v related?

Solution:

Here the negative value of magnification indicates that image is real and inverted. The magnitude of magnification is greater than 1, which means the image is enlarged. Hence, the lens should be convex lens.

The relation between u and v is given by

$m = v / u$

$-3 = v / -u$

$v = 3u$

This shows the image distance is 3 times that of object distance.

Question: 16

The magnification by a lens is +0.5. Name the lens and state how are u and v related?

Solution:

The image formed by the concave lens is always virtual, erect and smaller than the object. Hence, the magnification is always positive and less than 1

The relation between u and v is

$m = v / u$

$0.5 = -v / -u$

$1 / 2 = v / u$

$u = 2v$

Hence, the object distance is twice that of image distance.

Question: 17

A concave lens is a focal length 30 cm. Find the position and magnification (m) of image for an object placed in front of it at distance 30 cm. State whether the image is real on virtual?

Solution:

Given,

Object distance, u = -30 cm

Focal length, f = -30 cm

Image distance, v = ?

Len's formula is

$1 / f = 1 / v – 1 / u$

$1 / -30 = 1 / v – 1 / -30$

$1 / v = -1 / 30 – 1 / 30$

$1 / v = -2 / 30$

$1 / v = - 1 / 15$

$v = -15$

The relation between u and v is
m = v / u
m = -15 / -30
m = 0.5
∴ The image formed is virtual and erect

Question: 18
Find the position and magnification of the image of an object placed at distance of 8.0 cm in front of a convex lens of focal length 10.0 cm. Is the image erect or inverted?
Solution:
Given,
Object distance, u = - 8 cm
Focal length, f = 10 cm
Image distance v = ?
Len's formula is
1 / f = 1 / v – 1 / u
1 / 10 = 1 / v – 1 / -8
1 / v = 1 / 10 – 1 / 8
1 / v = (4 – 5) / 40
1 / v = - 1 / 40
v = - 40 cm
The object is placed between the focus and optical center of the lens. So the image formed is virtual and erect.

EXERCISE 5(D) PAGE NO: 131

Question: 1

What is magnifying glass? State its two uses.

Solution:

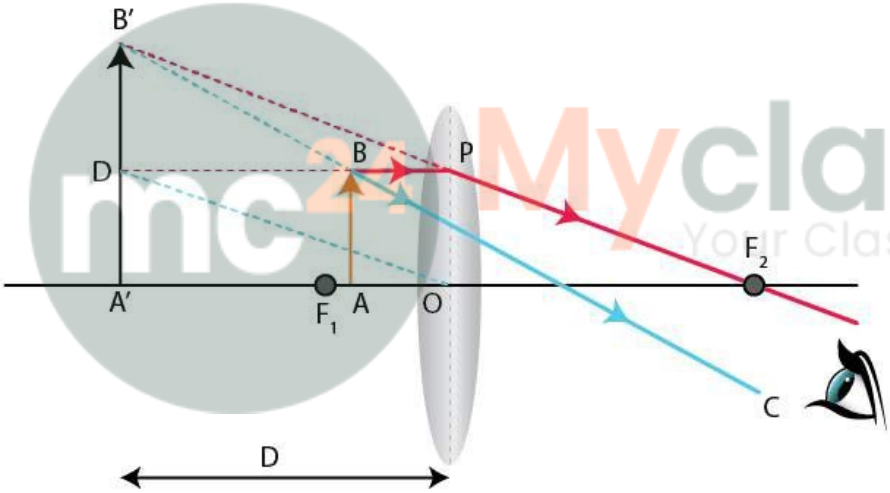
Magnifying glass is a convex lens of short focal length. It is mounted in a lens holder for practical use. It is used to see and read the small letters and figures and also used by watch makers to see the small parts and screws of the watch.

Question: 2

Draw a neat labelled ray diagram to locate the image formed by a magnifying glass. State three characteristics of the image.

Solution:

The image (A'B') of the object (AB) will form on the same side of lens when the object (AB) is situated between focal length and optical centre of a convex lens.



The image formed will be virtual, magnified and erect.

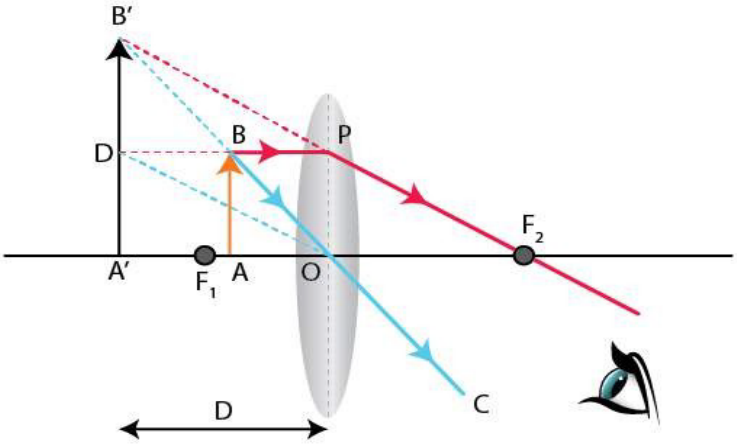
Question: 3

Where is the object placed in reference to the principal focus of a magnifying glass, so as to see its enlarged image? Where is the image obtained?

Solution:

The object is placed between the lens and principal focus

The image is obtained between the lens and principal focus.



Question: 4

Write expression for the magnifying power of a simple microscope. How can it be increased?

Solution:

The magnifying power of the microscope is given as

Magnifying power $M = 1 + D / f$

Where f is the focal length of the lens and D is the least distance of distinct vision

The magnifying power of the microscope be increased by using the lens of short focal length i.e shorter the focal length, more is the magnifying power. But it cannot be increased indefinitely.

Question: 5

State two applications each of a convex lens and concave lens.

Solution:

Application of a convex lens are

(i) The objective lens of a telescope, camera, slide projector, etc, is a convex lens which forms the real and inverted image of the object.

(ii) Our eye lens is also a convex lens. The eye lens forms the inverted image of the object on retina

Application of concave lens are

(i) A concave lens is used as the eye lens in a Galilean telescope to obtain the final erect image of the object.

(ii) A person suffering from short sightedness or myopia wears spectacles having concave lens.

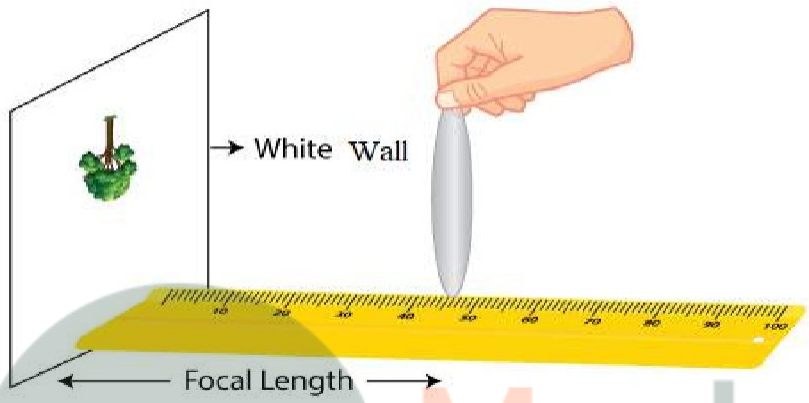
Question: 6

Describe in brief how would you determine the approximate focal length of a convex lens.

Solution:

The approximate focal length of a convex lens can be determined by using the principle that a beam of parallel rays incident from a distant object is converged in the focal plane of the lens.

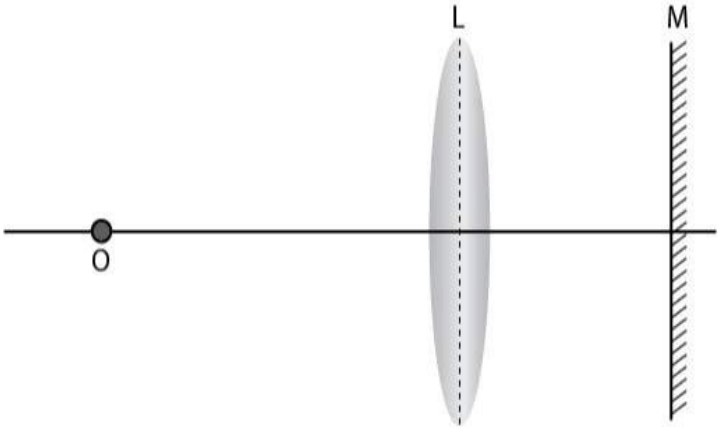
In an open space, against a white wall, a 0 cm end metre scale is placed horizontally touching the wall.



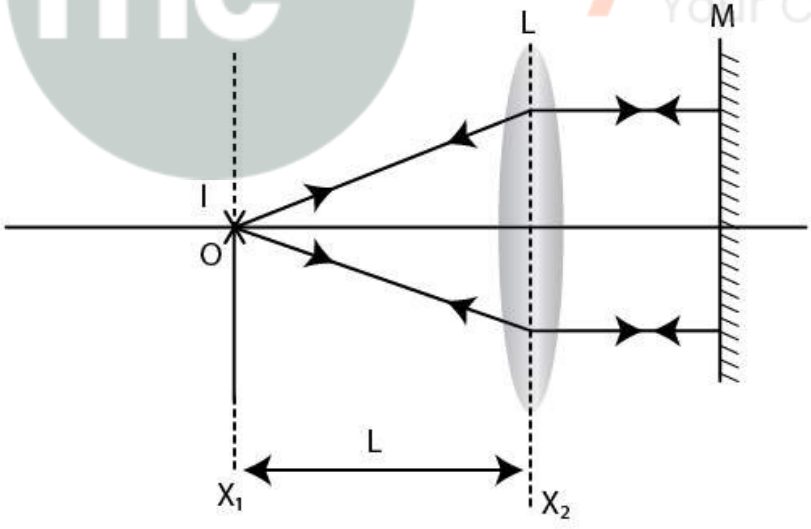
By moving the convex lens to and fro along the length of the metre rule, focus the object on wall. The image formed on the wall is almost at the focus of the lens and from the image, the distance of the lens is read directly by the metre scale. This gives the approximate focal length of the lens.

Question: 7

The diagram in Fig. shows the experimental set up for the determination of focal length of a lens using a plane mirror.



(i) Draw two rays from the point O of the object pin to show the formation of image I at O itself.
(ii) What is the size of the image I?
(iii) State two more characteristics of the image I.
(iv) Name the distance of the object O from the optical centre of the lens.
(v) To what point will the rays return if the mirror is moved away from the lens by a distance equal to the focal length of the lens?
Solution:



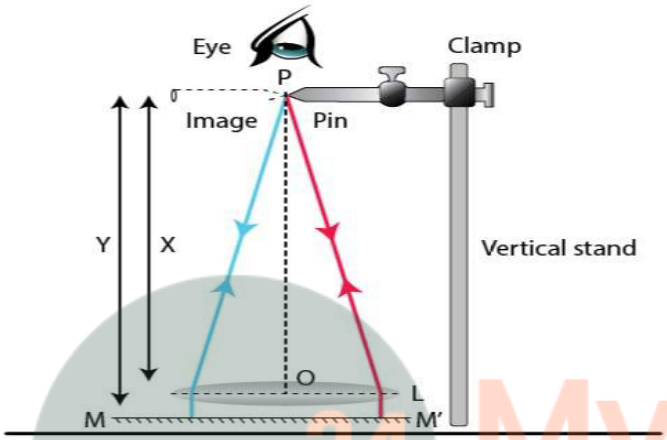
(ii) The size of the image will be same as that of object
(iii) The image formed will be real and inverted.
(iv) The distance of object O from optical lens will be equal to the focal length of the lens
(v) As long as the rays from the lens fall normally on the plane mirror M, the position of the mirror from lens does not affect the formation of image.

Question: 8

Describe how you would determine the focal length of a converging lens, using plane mirror and one pin. Draw a ray diagram to illustrate your answer.

Solution:

In order to determine the focal length by using plane mirror we need a vertical stand, a plane mirror, a lens and a pin. Place the lens L horizontally on a plane mirror MM'. Arrange the pin P in the clamp horizontally in such a way that the tip of pin is vertically above the centre O of the lens.



Adjust the height of the pin till it has no parallax (i.e if the pin and its image shift together) with its inverted image as seen from vertically above the pin.

Measure the distance x of the pin P from the lens and the distance y of the pin from the mirror, using a metre rule and a plumb line. Calculate the average of the two distances. This gives the focal length of the lens, i.e

$$f = (x + y) / 2$$

Question: 9

How will you differentiate between a convex and a concave lens by looking at (i) a distant object and (ii) a printed page?

Solution:

(i) On seeing a distant object through the lens, if its inverted image is seen, the lens is convex and if the upright image is seen, the lens is concave.

(ii) On keeping the lens near a printed page, if letters appear magnified, the lens is convex and if the letters appear diminished, the lens is concave.

MULTIPLE CHOICE TYPE

Question: 1

A magnifying glass forms:

(a) A real and diminished image

(b) A real and magnified image
(c) A virtual and magnified image
(d) A virtual and diminished image
Solution:
A magnifying glass forms a virtual and magnified image

Question: 2
The maximum magnifying power of a convex lens of focal length 5 cm can be:
(a) 25
(b) 10
(c) 1
(d) 6
Solution:

Given,
Focal length of convex lens, f = +5 cm
Magnifying power of convex lens (simple microscope) is
m = 1 + D / f
where D is the distance of the distinct vision, D = 25 cm
m = 1 + 25 / 5
m = 30 / 5
m = 6